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WEATHER CONSTRAINED THROUGHPUT: SUBSTITUTING SPANGDAHLEM AND RAMSTEIN FOR RHEIN MAIN

GRADUATE RESEARCH PROJECT

Richard P. MacKeen, Major, USAF

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Richard P. MacKeen, B.S., M.A.

Major, USAF

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My only regret is that I could not take on the subjects of concern for many of these people. There is enough material for more than five graduate research papers. Hopefully this paper can be a stepping stone for more study. Remember, you heard the words "weather constrained throughput" first here!

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Abstract

As the United States Air Force enters the 21st Century, it is transitioning from a strategy of forward presence to a force projection capability. This strategy has been adopted by the U.S. military as a whole and therefore, places a heavy reliance on the airlift capability of the United States Air Force.

As the operations out of Rhein Main AB are absorbed by Ramstein AB and Spangdahlem AB, Air Force leadership needs to be aware of the impact the weather differences have on operations. This paper looks at the operational differences between these bases from a standpoint of weather constrained throughput.

To get to the final weather constraining factors, a ten-year history of weather conditions at the bases in question were analyzed. The analysis was based off of the percent of each month that operations were limited due to ceiling, visibility, and crosswind limitations.

The final result is a group of tables containing correction factors that can be applied to each base on a monthly basis. The throughput can thus be corrected and more accurate planning can be accomplished in line with the Air Force concept of force projection and Mobility operations in support of humanitarian and disaster relief.

WEATHER CONSTRAINED THROUGHPUT:

SUBSTITUTING SPANGDAHLEM AND

RAMSTEIN FOR RHEIN MAIN

I. Introduction

Background

In the new era of cost cuts and subsequent reduction of the number of troops and equipment that are forward deployed, the Air Force has a vested interest in maintaining an infrastructure that will enable U.S. foreign policy makers to project military forces around the world. The 1998 TRANSCOM Posture Statement identifies the need to maintain six European bases capable of sustaining high volume mobility air operations. As the future use of Rhein Main Air Base (AB), Germany as a mobility staging base becomes history, Air Force leadership will be challenged to maintain existing capability from the different locations of Ramstein and Spangdahlem ABs.

Rhein Main AB is located across the runway in Frankfurt Germany. Rhein Main AB sits on property owned by the Frankfurt Aktien Gesellsehaft (FAG) and leased through the Federal Republic of Germany (FRG) by United States Air Forces Europe (USAFE). Frankfurt is Germany's largest commercial airport and Europe's second largest airport. Due to the nature of real estate development in Frankfurt, the

commercial airport cannot expand to meet future demands unless the land Rhein Main AB sits on is given back to the FAG.

In recent years there has been increasing pressure to negotiate the withdraw of US Forces from Rhein Main AB. The US Air Force has been given a green light by SECDEF to open formal negotiations with the FRG. If US Forces are going to be withdrawn from Rhein Main AB, then the FRG must pay, according to treaty, for this move in "Payment-in-Kind" (PIK) expenditures such that the readiness of US Forces will not be jeopardized. As of a 2 Jun 99 negotiation meeting in Frankfurt, the price tag for this move is estimated at 627.4 million DM ($358.5 M) for primary construction plus 110 ($62.8 M) million DM for incidental construction costs (Schmokel, 2 Jun 99). Of this amount, 283.8M DM are for projects at Spangdahlem AB and 409.95M DM are for Ramstein AB (Motz, 2 Jun 99). This current sum, according to Major Schmokel, is to be put forward to HQUSAF and the final return of Rhein Main AB to the FAG is eminent (Schmokel, 2 Jun 99).

Research Question

Air Force leadership has determined that closing Rhein Main AB and subsequent loss of mobility throughput can be substituted by increased operations out of Ramstein AB and Spangdahlem AB, Germany. The key question is "what are the operational differences in mobility throughput due to weather caused by substituting operations in Rhein Main AB with operations in Spangdahlem AB and Ramstein AB?"

Scope

The subject of closing Rhein Main is politically sensitive. This topic is very broad, so there are many questions that this GRP will not address. For example, is the decision to leave Rhein Main the right one? Is it possible to use Spangdahlem AB as an Army upload point? Can 24 hour operations occur at Spangdahlem and Ramstein AB without significant local national backlash?

In short, the larger issue of the weather differences between Rhein Main AB, Ramstein AB, and Spangdahlem AB can be expanded upon to aid decision-makers. There has not been a comparison of the weather results for specific weather categories and crosswind limits to throughput capability.

Air Force decision-makers need to be able to use the weather equation when determining MRS BURU limits. Knowing the limitations to throughput can allow more accurate planning for the Two Major Theater War (2MTW) scenarios. The "six plus one" European basing strategy can be more adequately fine-tuned by knowing the weather limitations.

Assumptions/Limitations

Daily operations during time of war include mass movement of troops and supplies through aerial ports. These troops and supplies belong to all the services: Air Force, Army, Navy & Marines. Any decision to change the throughput of logistics

needs to be coordinated not just with the host nation, but also with all agencies that are involved.

United Air Forces Europe (USAFE) has conducted an extensive study and has put forward the concept to relocate the Airlift mission from Rhein Main to Ramstein and Spangdahlem Air Bases, Germany. This research project will act to augment US Air Force decision makers to determine if all the air mobility issues have been taken into account in the area of "weather constrained throughput" (WCT) and to verify if all the customers will be satisfied with the final outcome.

Overview of Subsequent Chapters

To better understand how the closing of Rhein Main AB will affect the Air Force Mobility mission we will explore the results of data of the last ten years of weather from the bases in question. Chapter II will cover the methodology used to explore the statistical analysis done on the data from each base. Chapter III will give the results of each base using ceiling, visibility, crosswinds, and a combination of ceiling and visibility. Chapter IV will compare and contract the findings of Chapter III. Chapter V will analyze the weather data from an operational throughput angle, comparing the throughput ability of each of the three bases using weather as the constraint. Lastly, chapter VI will summarize the findings and give specific recommendations.

II. Methodology

Background

The methodology of how the data was used will be useful in understanding this paper. More importantly, by understanding how the data was manipulated, further research will be possible to expand on these results.

The basis for this paper is a data run from the Air Force Combat Climate Center (AFCCC) and is available from the author in an excel spreadsheet form, or directly from the AFCCC. The data consists of the last ten years of weather data for Rhein Main, Ramstein, and Spangdahlem Air Bases. This data is actual hourly and special observed weather. In other words, this is not forecast data, but it is what actually occurred. None of the data used will have any forecast algorithms attached in any way. All tables and figures derived from the data manipulation will not be referenced except to say here that these tables and figures reflect the raw data manipulation from the data provided by the AFCCC. The tables and figures are the author's creation from said raw data.

Theory/Assumptions

The basic data that was provided consisted of weather observations for the years 1989 through 1998. Table 1 shows the relationship of the basic data to the final data that was used in this paper.

Table 1. Raw Vs. Refined Data

	Raw Data Points	Refined Data Points		
	Combined	Ceiling	Visibility	Crosswinds
Rhein Main	162,900	84,089	83,629	84,090
Ramstein	114,391	87,103	86,989	86,855
Spangdahlem	112,035	85,297	85,313	85,296
Total	389,326	256,489	255,931	256,241

As you can see, there were 162,900, 114,391, and 112,035 weather observations for specific times for each of Rhein Main, Ramstein, and Spangdahlem Air Bases respectively. The actual data used varied according to the phenomena being measured. These varied between 84,089 and 87,103 observations. The actual data entries that were used varied greatly from the total 389,326 observations due to one main reason. Raw data included all observations for odd hours and also special observations for weather changes. For the purpose of comparing the three bases to each other, it was necessary to only use the observations that occurred on each hour. Thus, the average hours per month of a particular weather phenomenon could be determined for a comparative analysis of the three bases.

Another observation would show that the actual hourly observations did not equal the total possible hours available for the ten years measurement period. There are 87,600 hours in ten years. Table 2 shows the percent of refined data used compared to the total possible available hours.

Table 2. Percentage of Refined Data Used

	Refined Data Points					
	Ceiling	% of Possible	Visibility	% of Possible	Crosswinds	% of Possible
Rhein Main	84,089	95.99%	83,629	95.47%	84,090	95.99%
Ramstein	87,103	99.43%	86,989	99.30%	86,855	99.15%
Spangdahlem	85,297	97.37%	85,313	97.39%	85,296	97.37%
Total	256,489		255,931		256,241	

Each observation contained the following information: station number, year, month, day, observation type, hour (zulu), wind direction/speed, visibility (meters), present weather, sky condition, dry bulb temp (deg C), dew point temp (deg C), altimeter setting, ceiling (feet), and remarks. For future reference, the station numbers are as follows: Rhein Main #106370, Ramstein #106140, and Spangdahlem #106070.

Three primary measurements were used from each observation; ceiling, visibility, and winds. Each of these primary measurements is arranged by year, month, and hour. You will note that Table 2 also shows discrepancies for the same base in these three primary measurements. For example, Ramstein has 87,103 measurements for ceiling and 86,989 for visibility. These discrepancies are a result of human error on the part of the weather personnel at each station. These personnel did not make a complete entry in the data base and as such ceiling may have been reported correctly, but the information placed in the visibility section was either not legible or the information was omitted.

The question of sample size is the biggest assumption that I have made. The data used only takes into account the last ten years of observations. This was done for a number of reasons: to limit the discussion to a manageable amount of data, because statistical analysis was going to be limited to averages (i.e. distribution curves were not going to be used), and because monthly averages included a sufficient sample size to validate the conclusions. Thus, the comparative nature of this study will be served by a ten-year average.

According to Capt Jonathan Thompson, a staff meteorologist at the AFCCC, ten years of data will be adequate to provide "general planning capability" (Thompson, 1999). The study of meteorology "gives a general feel" for weather phenomena, but is

"not very good at capturing extreme events" (Thompson, 1999). For the purpose of this paper, ten years of data will be a good comparative tool and will allow general planning and comparisons at a high degree of accuracy. One final point is that forecast models, whether military or civilian, are only accurate up to 72 hours before the event, and after that point they are only effective 50% of the time (Thompson, 1999).

The final assumption that is made in this paper is that 24-hour operations will be possible at all bases. It is important to note that this is not the current situation at Ramstein and Spangdahlem ABs. The realignment of the runway at Ramstein will allow for 24-hour operations once complete (Schmokel, 8 Feb 99). Negotiations with the German authorities and townspeople around Spangdahlem will have to be conducted in order to procure rights to 24-hour operations there. This paper will try not to get too involved with the political implications of these operations, but note that this could significantly alter the results of this study.

Summary

The data, in the form of weather observations, was limited to each hour to better make comparisons to the other bases. Extraneous entries, due to human input error, in this data were not used and account for the disparity between the number of observations used. The disparity is not too great to make this data invalid as the vast majority of the observations are accounted for. Chapter III will go into greater detail of the results of the data manipulation.

III. Data

Background

The focus of the data manipulation was to break from each observation three pieces of information. These three included ceiling, visibility, and wind phenomena that would restrict the ability of Air Force Mobility assets from landing at these bases. This chapter will lay out the results of the data manipulation in both tabular and graphical format. Chapter IV will go into greater detail, comparing these tables and graphs. This chapter is broken into four sections. These sections include separate discussions on ceiling, visibility, crosswinds, and a combination of ceiling and visibility.

The concept of Instrument Categories is also part of the results and needs an introduction. Category I is equal to a ceiling as low as 200 feet and a visibility of one mile or 800 meters. Category II is equal to a ceiling as low as 100 feet and a visibility of ½ mile, 1240 Runway Visual Range (RVR), or 400 meters RVR (AFM 11-217, 1996:24.1). Category III is broken down into three subsections. These values are summarized by the FAA in Table 3.

Table 3. Category III Landing Weather Minima (FAA, 1984)

Category	Decision Height (ft)	RVR (ft)	RVR (m)
IIIa	0 to < 100	> = 700	> = 200
IIIb	0 to < 50	> = 150, < 700	> = 50, < 200
IIIc	0	0	0

Runway visual range (RVR) is a mechanical measurement between transmitsometers located on each aerodrome. This measurement is given when the

Prevailing Visibility (done visually by weather forecasters) is less than or equal to one mile or the RVR is less than or equal to 6000 feet (AFM 15-111, section 6.4.2.4, 1996).

Ceiling

This section details the results of the refined data manipulation for each of the bases in question in regard to ceiling. The data is broken into two sections for Tables 4 – 6, ten year totals and ten year averages. Each table of basic data has the frequency of hours that the observations for ceilings were 0 through 400 feet. Cat I and Cat II data is listed by the hourly frequency that the ceiling is ***out*** of that category limit. For example, in Table 4 there were 176 hours in Jan during the past ten years when Rhein Main was out of Cat I limits. The monthly average for the same example is 17.6 hours per month.

Rhein Main AB

The individual results of weather data for Rhein Main AB are listed in Table 4

Table 4. Rhein Main AB Basic Ceiling Data

Rhein Main

Basic Ceiling Table (Feet)

	10 Year Totals										10 Year Average						
	000	100	200	300	400	Cat I	Cat II	Out Of	Possible	%	000	100	200	300	400	Cat I	Cat II
Jan	83	93	118	219	126	176	83	7247	7440	0.974059	8.3	17.6	29.4	51.3	63.9	17.6	8.3
Feb	127	69	71	111	57	196	127	6577	6720	0.97872	12.7	19.6	26.7	37.8	43.5	19.6	12.7
Mar	12	9	6	18	10	21	12	7242	7440	0.973387	1.2	2.1	2.7	4.5	5.5	2.1	1.2
Apr	2	7	5	11	15	9	2	7051	7200	0.979306	0.2	0.9	1.4	2.5	4	0.9	0.2
May	4	6	4	5	7	10	4	7308	7440	0.982258	0.4	1	1.4	1.9	2.6	1	0.4
Jun	5	3	2	10	6	8	5	6937	7200	0.963472	0.5	0.8	1	2	2.6	0.8	0.5
Jul	5	4	7	12	7	9	5	6807	7440	0.914919	0.5	0.9	1.6	2.8	3.5	0.9	0.5
Aug	3	4	8	4	5	7	3	6863	7440	0.922446	0.3	0.7	1.5	1.9	2.4	0.7	0.3
Sep	16	11	7	24	17	27	16	6776	7200	0.941111	1.6	2.7	3.4	5.8	7.5	2.7	1.6
Oct	92	62	42	82	50	154	92	7238	7440	0.972849	9.2	15.4	19.6	27.8	32.8	15.4	9.2
Nov	132	124	109	173	86	256	132	6983	7200	0.969861	13.2	25.6	36.5	53.8	62.4	25.6	13.2
Dec	56	86	121	170	126	142	56	7060	7440	0.948925	5.6	14.2	26.3	43.3	55.9	14.2	5.6

Figure 1 shows the results of the ten year average for Rhein Main. Note that additional data is given in both Table 4 and Figure 1 that does not translate directly to Cat I or Cat II limitations. In particular, the ceilings of 300 and 400 feet are given to show general trend in weather and to be used for future study. This is the same for all bases.

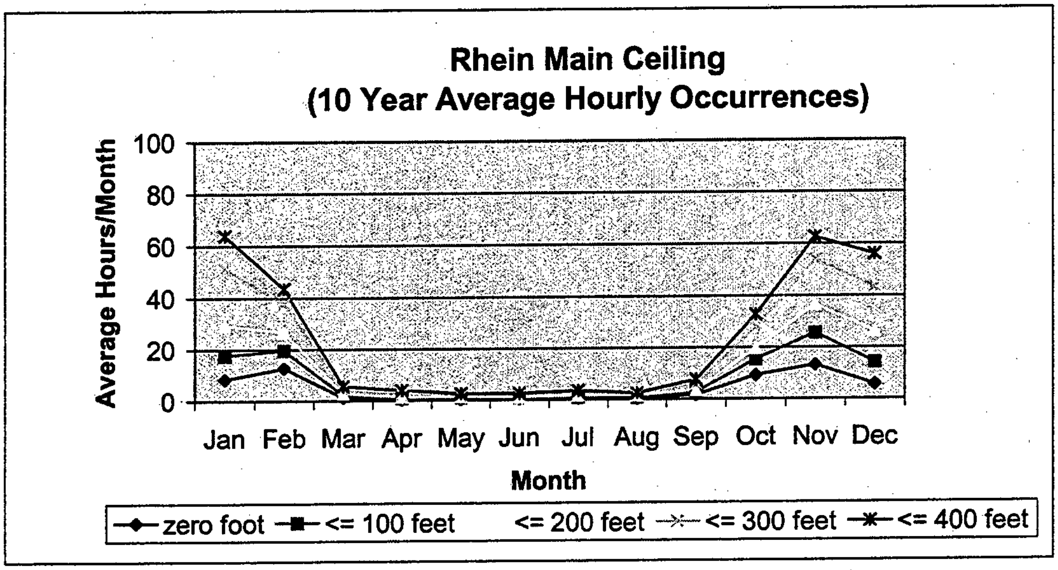

Figure 1. Rhein Main AB Ten Year Ceiling Monthly Averages

Ramstein AB

The individual results of weather data for Ramstein AB are listed in Table 5

Table 5. Ramstein AB Basic Ceiling Data

Ramstein	Basic Ceiling Table (Feet)																
	10 Year Totals										10 Year Average						
	000	100	200	300	400	Cat I	Cat II	Out Of	Possible	%	000	100	200	300	400	Cat I	Cat II
Jan	48	60	161	234	165	108	48	7389	7440	0.9931	4.8	10.8	26.9	50.3	66.8	10.8	4.8
Feb	29	89	154	141	129	118	29	6712	6720	0.9988	2.9	11.8	27.2	41.3	54.2	11.8	2.9
Mar	35	22	30	9	7	57	35	7402	7440	0.9949	3.5	5.7	8.7	9.6	10.3	5.7	3.5
Apr	18	11	17	13	18	29	18	7159	7200	0.9943	1.8	2.9	4.6	5.9	7.7	2.9	1.8
May	37	1	9	5	1	38	37	7350	7440	0.9879	3.7	3.8	4.7	5.2	5.3	3.8	3.7
Jun	10	4	6	2	0	14	10	7188	7200	0.9983	1	1.4	2	2.2	2.2	1.4	1
Jul	14	6	6	11	0	20	14	7434	7440	0.9992	1.4	2	2.6	3.7	3.7	2	1.4
Aug	14	16	16	9	2	30	14	7387	7440	0.9929	1.4	3	4.6	5.5	5.7	3	1.4
Sep	53	23	40	36	12	76	53	7179	7200	0.9971	5.3	7.6	11.6	15.2	16.4	7.6	5.3
Oct	132	99	76	56	53	231	132	7418	7440	0.997	13.2	23.1	30.7	36.3	41.6	23.1	13.2
Nov	48	99	121	123	449	147	48	7144	7200	0.9922	4.8	14.7	26.8	39.1	84	14.7	4.8
Dec	45	17	87	197	195	62	45	7341	7440	0.9867	4.5	6.2	14.9	34.6	54.1	6.2	4.5

Figure 2 shows the results of the ten year average for Ramstein AB.

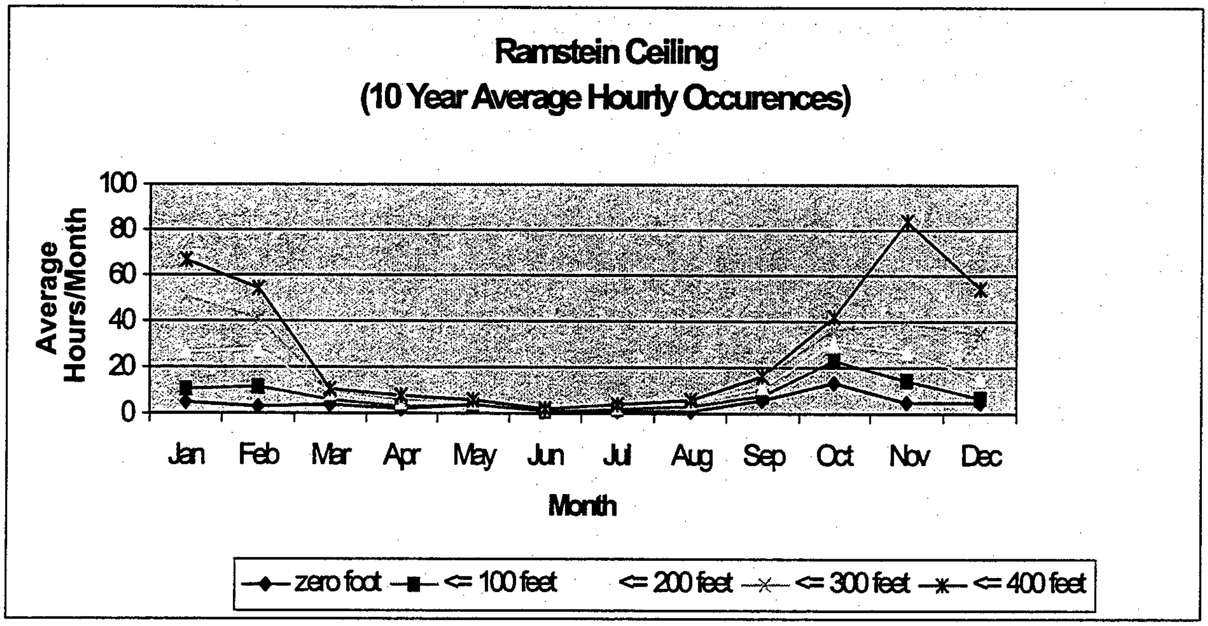

Figure 2. Ramstein AB Ten Year Ceiling Monthly Averages

SpangdahlemAB

The individual results of weather data for Spangdahlem AB are listed in Table 6

Table 6. Spangdahlem AB Basic Ceiling Data

Spangdahlem																	
	Basic Ceiling Table (Feet)																
	10 Year Totals										10 Year Average						
	000	100	200	300	400	Cat I	Cat II	Out Of	Possible	%	000	100	200	300	400	Cat I	Cat II
Jan	141	661	276	212	266	802	141	7214	7440	0.969624	14.1	80.2	107.8	129	155.6	80.2	14.1
Feb	52	318	164	128	80	370	52	6718	6720	0.999702	5.2	37	53.4	66.2	74.2	37	5.2
Mar	20	48	50	36	66	68	20	7390	7440	0.99328	2	6.8	11.8	15.4	22	6.8	2
Apr	5	23	35	46	33	28	5	7122	7200	0.989167	0.5	2.8	6.3	10.9	14.2	2.8	0.5
May	6	13	19	24	9	19	6	7266	7440	0.976613	0.6	1.9	3.8	6.2	7.1	1.9	0.6
Jun	15	7	27	27	32	22	15	7055	7200	0.979861	1.5	2.2	4.9	7.6	10.8	2.2	1.5
Jul	17	5	27	20	28	22	17	7315	7440	0.983199	1.7	2.2	4.9	6.9	9.7	2.2	1.7
Aug	10	23	22	21	23	33	10	7385	7440	0.992608	1	3.3	5.5	7.6	9.9	3.3	1
Sep	20	34	36	51	34	54	20	6943	7200	0.964306	2	5.4	9	14.1	17.5	5.4	2
Oct	71	102	113	83	98	173	71	7390	7440	0.99328	7.1	17.3	28.6	36.9	46.7	17.3	7.1
Nov	72	247	242	199	194	319	72	6784	7200	0.942222	7.2	31.9	56.1	76	95.4	31.9	7.2
Dec	66	398	400	205	185	464	66	6715	7440	0.902554	6.6	46.4	86.4	106.9	125.4	46.4	6.6

Figure 3 shows the results of the ten year average for Spangdahlem AB. Note that Figure 3 is the same scale as Figures 1 and 2 so that the differences can be seen.

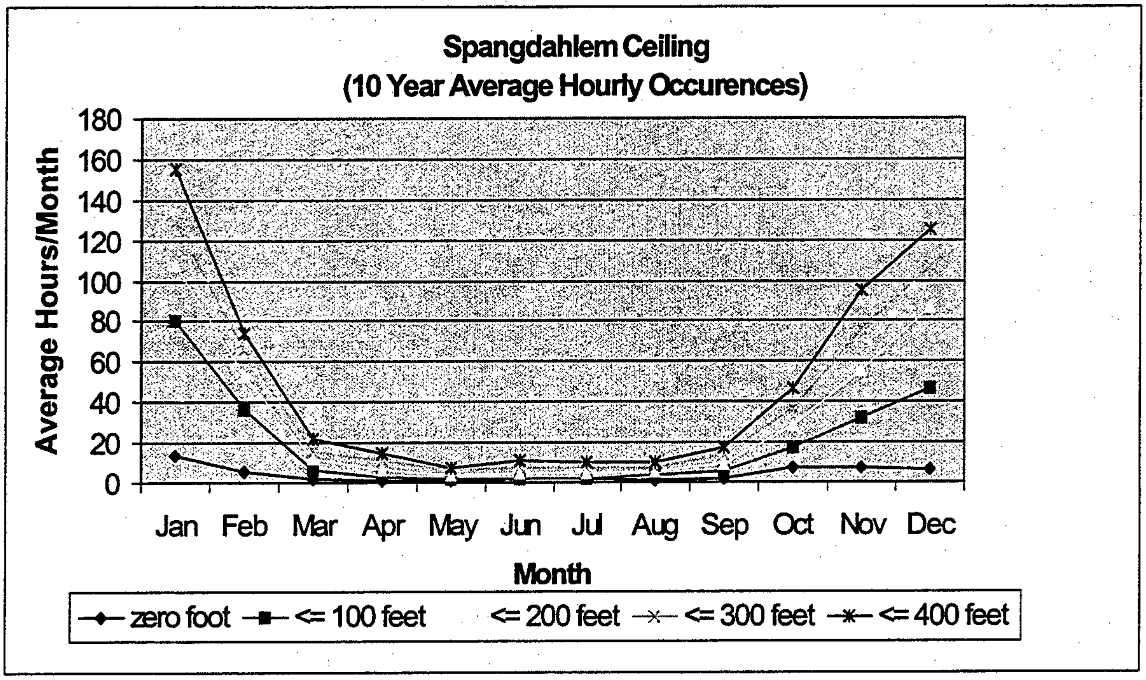

Figure 3. Spangdahlem AB Ten Year Ceiling Monthly Averages

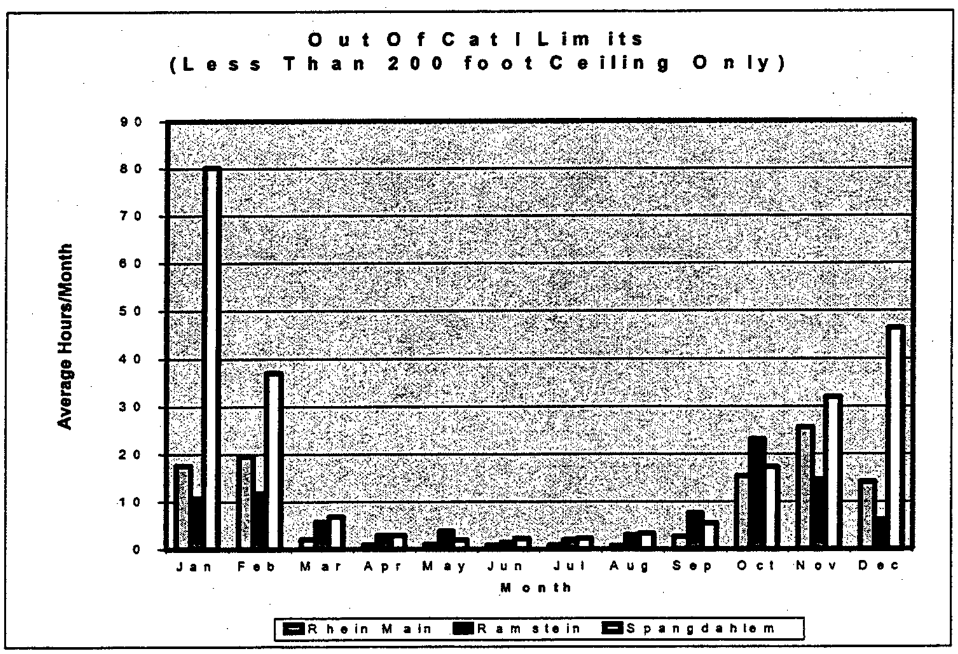

Figure 4. Out Of Cat I Limits, Ceiling Only

Cat I

Figure 4 shows a comparison of all the bases with respect to out of Category I ceiling limits. Note that this is ceiling only. Categories usually combine both ceiling and visibility. This will be done in the last section of this Chapter.

Cat II

Figure 5 shows a comparison of all the bases with respect to out of Category II ceiling limits.

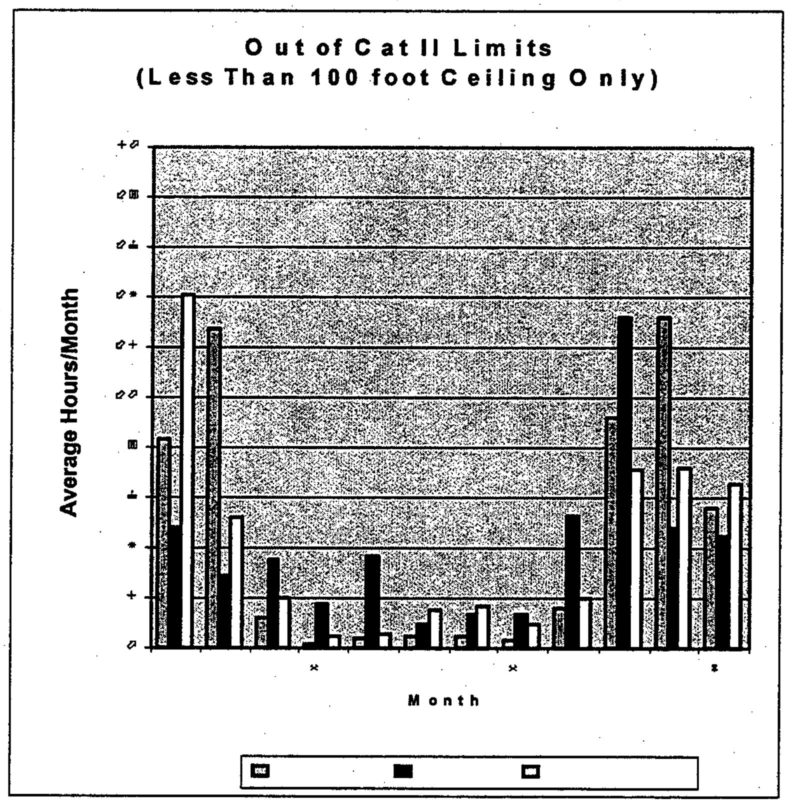

Figure 5. Out of Cat II Limits, Ceiling Only

Visibility

This section deals with the visibility of the bases in question. Visibility is the measurement of interest for AMC. Without going into too much detail about required alternates, AMC will allow aircraft to shoot approaches if the visibility is within limits.

You will note that more information, similar to the ceiling data, is included for use in further study and to provide trend information to the reader. The range of visibility is from zero to 800 meters. Meters are used because this is the primary visibility measurement for all European bases. Also, note that the individual occurrences of these selected visibility's are mutually exclusive and do not have anything to do with ceiling. As stated earlier, ceiling and visibility will be discussed later.

The data for visibility has been put into two different tables. The two types of data include ten-year totals and ten-year averages, similar to the ceiling data. The ten-year totals include information on the number of hours that observations were available. The number of possible observation was figured using the numbers of hours in a day times the days in a year times ten years. A percentage of data used is simply the number of observations divided by the numbers of hours in one year. The percent reflects a non-statistical confidence indicator of how accurate the data is.

The ten-year average data is inclusive. In other words, the visibility for each column includes that value and below. For example, the visibility of 400 meters includes the average of all occurrences of 400 meters and below. In addition, this table includes Category IIIa and IIIb (Refer to Table 2 for a discussion on the requirements

for these categories). Note that the data table and subsequent graphs give the average monthly hours visibility is out of the corresponding category limit.

The weather community does not report visibility in 50-meter increments. For this reason, Cat IIIa data is not as accurate as it could be. The data in Cat IIIa reflects the occurrences of visibility of 100 or less. Cat IIIb data includes only visibility of zero. It would be a good idea to capture 50meter data, as it could validate or invalidate Cat III approach requirements for future installation.

Rhein Main

Table 7 shows the basic visibility data for Rhein Main AB. The columns show hourly occurrences of visibility in meters for the last ten years. For example, between 1989 and 1998 there were Twenty-two hours of a visibility of 400 meters for the month of October.

Table 7. Rhein Main AB Ten Year Visibility Totals

Rhein Main

Basic Visibility (Meters)
10 Year Totals

	0	100	200	300	400	500	600	700	800	Out Of	Possible	%
Jan	2	11	19	15	21	23	20	15	25	7247	7440	0.9741
Feb	8	14	25	26	16	15	14	16	19	6577	6720	0.9787
Mar	0	0	1	4	2	1	6	3	2	7242	7440	0.9734
Apr	0	0	2	0	1	1	3	0	2	7051	7200	0.9793
May	2	2	0	1	1	1	1	1	0	7308	7440	0.9823
Jun	0	0	1	1	0	1	3	0	3	6938	7200	0.9636
Jul	0	1	1	3	1	2	0	1	1	6807	7440	0.9149
Aug	0	1	2	0	2	2	0	0	0	6863	7440	0.9224
Sep	1	2	5	5	2	5	2	4	2	6776	7200	0.9411
Oct	3	25	21	20	22	15	14	12	21	6776	7440	0.9108
Nov	1	11	29	36	33	26	24	25	20	6983	7200	0.9699
Dec	1	5	6	20	22	22	21	16	15	7061	7440	0.9491

Table 8 shows the ten-year average hours per month of the specific visibility in each column and below for Rhein Main AB. The category data is given as the average hours per month that the visibility only is out of each category limit.

Table 8. Rhein Main AB Ten Year Visibility Averages

Rhein Main

Basic Visibility (Meters)
10 Year Average

	At and Below									Out of Cat Limits			
	0	**100**	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**Cat IIIb**	**Cat IIIa**	**Cat II**	**Cat I**
Jan	0.2	1.3	3.2	4.7	6.8	9.1	11.1	12.6	15.1	0.2	1.3	4.7	12.6
Feb	0.8	2.2	4.7	7.3	8.9	10.4	11.8	13.4	15.3	0.8	2.2	7.3	13.4
Mar	0.0	0.0	0.1	0.5	0.7	0.8	1.4	1.7	1.9	0.0	0.0	0.5	1.7
Apr	0.0	0.0	0.2	0.2	0.3	0.4	0.7	0.7	0.9	0.0	0.0	0.2	0.7
May	0.2	0.4	0.4	0.5	0.6	0.7	0.8	0.9	0.9	0.2	0.4	0.5	0.9
Jun	0.0	0.0	0.1	0.2	0.2	0.3	0.6	0.6	0.9	0.0	0.0	0.2	0.6
Jul	0.0	0.1	0.2	0.5	0.6	0.8	0.8	0.9	1.0	0.0	0.1	0.5	0.9
Aug	0.0	0.1	0.3	0.3	0.5	0.7	0.7	0.7	0.7	0.0	0.1	0.3	0.7
Sep	0.1	0.3	0.8	1.3	1.5	2.0	2.2	2.6	2.8	0.1	0.3	1.3	2.6
Oct	0.3	2.8	4.9	6.9	9.1	10.6	12.0	13.2	15.3	0.3	2.8	6.9	13.2
Nov	0.1	1.2	4.1	7.7	11.0	13.6	16.0	18.5	20.5	0.1	1.2	7.7	18.5
Dec	0.1	0.6	1.2	3.2	5.4	7.6	9.7	11.3	12.8	0.1	0.6	3.2	11.3

The data in Table 8 is graphically represented in Figure 6 (Visibility Only).

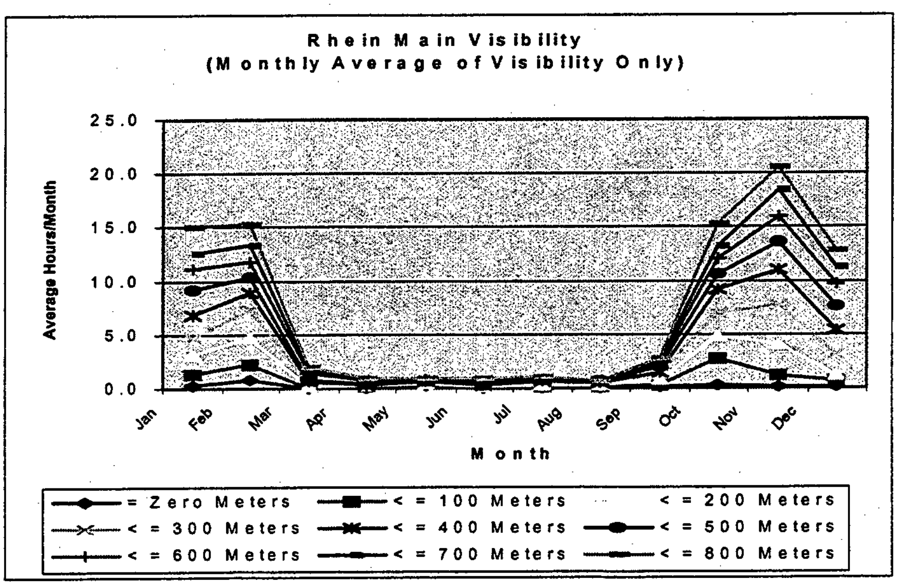

Figure 6. Rhein Main Average Visibility in Hours per Month

Ramstein

Table 9 shows the basic visibility data for Ramstein AB. The columns show hourly occurrences of visibility in meters for the last ten years. For example, between 1989 and 1998 there were Fifty-two hours of a visibility of 200 meters for the month of September.

Table 9. Ramstein AB Ten Year Visibility Totals

Ramstein

Basic Visibility (Meters)
10 Year Totals

	0	100	200	300	400	500	600	700	800	Out Of	Possible	%
Jan	1	15	56	44	34	39	27	21	35	7359	7440	98.9%
Feb	0	50	75	44	45	28	43	10	68	6713	6720	99.9%
Mar	0	6	56	27	24	13	8	10	33	7403	7440	99.5%
Apr	1	14	21	18	17	7	2	5	44	7176	7200	99.7%
May	0	22	42	17	19	11	8	14	32	7440	7440	100.0%
Jun	0	13	26	12	14	9	6	8	26	7183	7200	99.8%
Jul	0	8	30	12	4	4	7	3	25	7436	7440	99.9%
Aug	0	11	24	8	6	12	12	12	23	7334	7440	98.6%
Sep	8	29	52	36	37	17	20	21	29	7151	7200	99.3%
Oct	1	19	55	42	29	25	20	15	29	7385	7440	99.3%
Nov	3	13	52	28	28	8	13	7	22	7129	7200	99.0%
Dec	0	13	26	20	14	19	28	14	25	7280	7440	97.8%

Table 10 shows the ten-year average hours per month of the specific visibility in each column and below for Ramstein AB. The category data is given as the average hours per month that the visibility only is out of each category limit.

Table 10. Ramstein AB Ten Year Visibility Averages

Ramstein

Basic Visibility (Meters)
10 Year Average

	At And Below									Out of Cat Limits			
	0	100	200	300	400	500	600	700	800	Cat IIIb	Cat IIIa	Cat II	Cat I
Jan	0.1	1.6	7.2	11.6	15.0	18.9	21.6	23.7	27.2	0.1	1.6	11.6	23.7
Feb	0.0	5.0	12.5	16.9	21.4	24.2	28.5	29.5	36.3	0.0	5.0	16.9	29.5
Mar	0.0	0.6	6.2	8.9	11.3	12.6	13.4	14.4	17.7	0.0	0.6	8.9	14.4
Apr	0.1	1.5	3.6	5.4	7.1	7.8	8.0	8.5	12.9	0.1	1.5	5.4	8.5
May	0.0	2.2	6.4	8.1	10.0	11.1	11.9	13.3	16.5	0.0	2.2	8.1	13.3
Jun	0.0	1.3	3.9	5.1	6.5	7.4	8.0	8.8	11.4	0.0	1.3	5.1	8.8
Jul	0.0	0.8	3.8	5.0	5.4	5.8	6.5	6.8	9.3	0.0	0.8	5.0	6.8
Aug	0.0	1.1	3.5	4.3	4.9	6.1	7.3	8.5	10.8	0.0	1.1	4.3	8.5
Sep	0.8	3.7	8.9	12.5	16.2	17.9	19.9	22.0	24.9	0.8	3.7	12.5	22.0
Oct	0.1	2.0	7.5	11.7	14.6	17.1	19.1	20.6	23.5	0.1	2.0	11.7	20.6
Nov	0.3	1.6	6.8	9.6	12.4	13.2	14.5	15.2	17.4	0.3	1.6	9.6	15.2
Dec	0.0	1.3	3.9	5.9	7.3	9.2	12.0	13.4	15.9	0.0	1.3	5.9	13.4

The data in Table 10 is graphically represented in Figure 7. Note that Figure 7 represents visibility only.

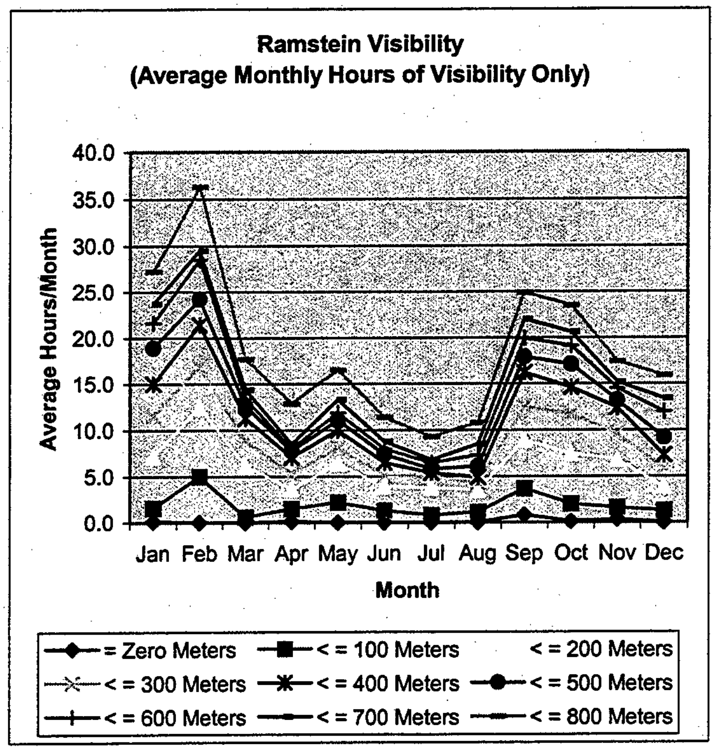

Figure 7. Ramstein Average Visibility in Hours per Month

Spangdahlem

Table 11 shows the basic visibility data for Spangdahlem AB. The columns show hourly occurrences of visibility in meters for the last ten years. For example, between 1989 and 1998 there were Thirty-nine hours of a visibility of 700 meters for the month of January.

Table 11. Spangdahlem AB Ten Year Visibility Totals

Spangdahlem

Basic Visibility (Meters)
10 Year Totals

	0	100	200	300	400	500	600	700	800	Out Of	Possible	%
Jan	11	295	245	137	112	47	47	39	96	7215	7440	0.9698
Feb	10	192	162	109	98	46	42	36	80	6719	6720	0.9999
Mar	0	10	37	9	23	13	16	17	23	7390	7440	0.9933
Apr	0	4	14	15	12	9	5	3	13	7123	7200	0.9893
May	0	12	8	14	8	2	5	3	9	7266	7440	0.9766
Jun	0	0	17	6	11	5	2	1	10	7058	7200	0.9803
Jul	1	12	8	7	12	3	4	0	16	7318	7440	0.9836
Aug	2	21	18	11	6	6	9	2	11	7386	7440	0.9927
Sep	1	25	31	23	19	14	10	6	17	6944	7200	0.9644
Oct	10	67	91	39	42	32	17	9	34	7392	7440	0.9935
Nov	11	82	106	69	67	34	40	37	79	6786	7200	0.9425
Dec	8	130	156	92	80	55	58	48	96	6716	7440	0.9027

Table 12 shows the ten-year average hours per month of the specific visibility in each column and below for Spangdahlem AB. The category data is given as the average hours per month that the visibility only is out of each category limit.

Table 12. Spangdahlem AB Ten Year Visibility Averages

Spangdahlem

Basic Visibility (Meters)
10 Year Average

	At And Below									Out of Cat Limits			
	0	**100**	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**Cat IIIb**	**Cat IIIa**	**Cat II**	**Cat I**
Jan	1.1	30.6	55.1	68.8	80.0	84.7	89.4	93.3	102.9	1.1	30.6	68.8	93.3
Feb	1.0	20.2	36.4	47.3	57.1	61.7	65.9	69.5	77.5	1.0	20.2	47.3	69.5
Mar	0.0	1.0	4.7	5.6	7.9	9.2	10.8	12.5	14.8	0.0	1.0	5.6	12.5
Apr	0.0	0.4	1.8	3.3	4.5	5.4	5.9	6.2	7.5	0.0	0.4	3.3	6.2
May	0.0	1.2	2.0	3.4	4.2	4.4	4.9	5.2	6.1	0.0	1.2	3.4	5.2
Jun	0.0	0.0	1.7	2.3	3.4	3.9	4.1	4.2	5.2	0.0	0.0	2.3	4.2
Jul	0.1	1.3	2.1	2.8	4.0	4.3	4.7	4.7	6.3	0.1	1.3	2.8	4.7
Aug	0.2	2.3	4.1	5.2	5.8	6.4	7.3	7.5	8.6	0.2	2.3	5.2	7.5
Sep	0.1	2.6	5.7	8.0	9.9	11.3	12.3	12.9	14.6	0.1	2.6	8.0	12.9
Oct	1.0	7.7	16.8	20.7	24.9	28.1	29.8	30.7	34.1	1.0	7.7	20.7	30.7
Nov	1.1	9.3	19.9	26.8	33.5	36.9	40.9	44.6	52.5	1.1	9.3	26.8	44.6
Dec	0.8	13.8	29.4	38.6	46.6	52.1	57.9	62.7	72.3	0.8	13.8	38.6	62.7

The data in Table 12 is graphically represented in Figure 8. Note that Figure 8 represents visibility only.

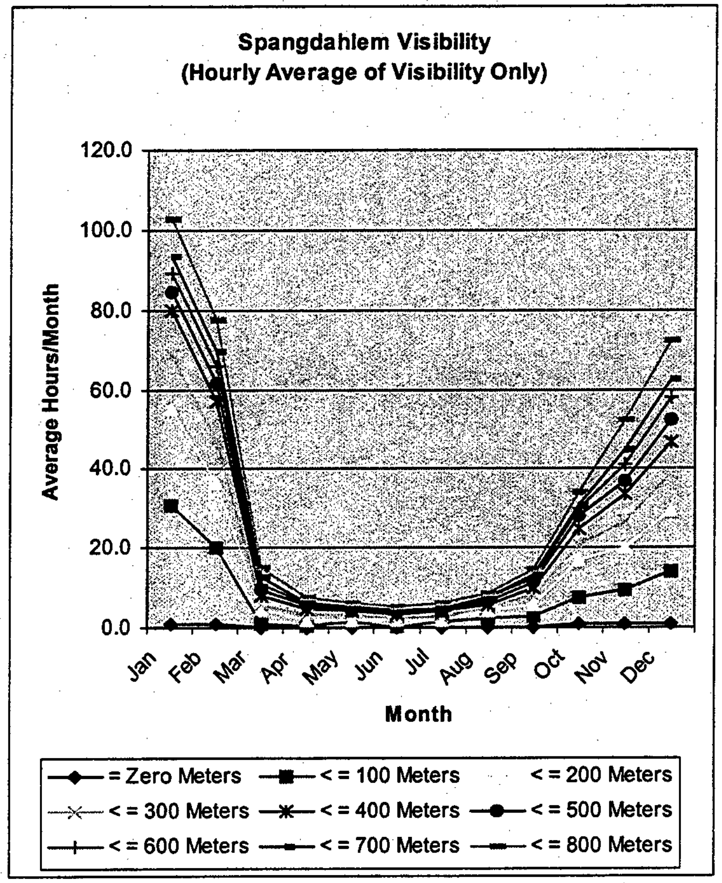

Figure 8. Spangdahlem AB Average Visibility in Hours per Month

Cat I

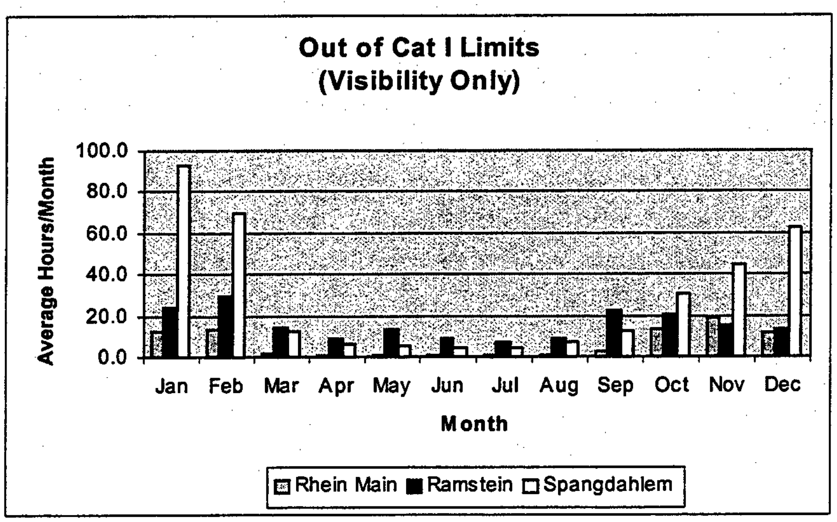

Figure 9. Out of Cat I Limits, Visibility Only

Figure 9 represents the average hourly occurrences that the visibility only was out of Cat I limits for all the bases in question.

Cat II

Figure 10 represents the average hourly occurrences that the visibility only was out of Cat II limits for all the bases in question.

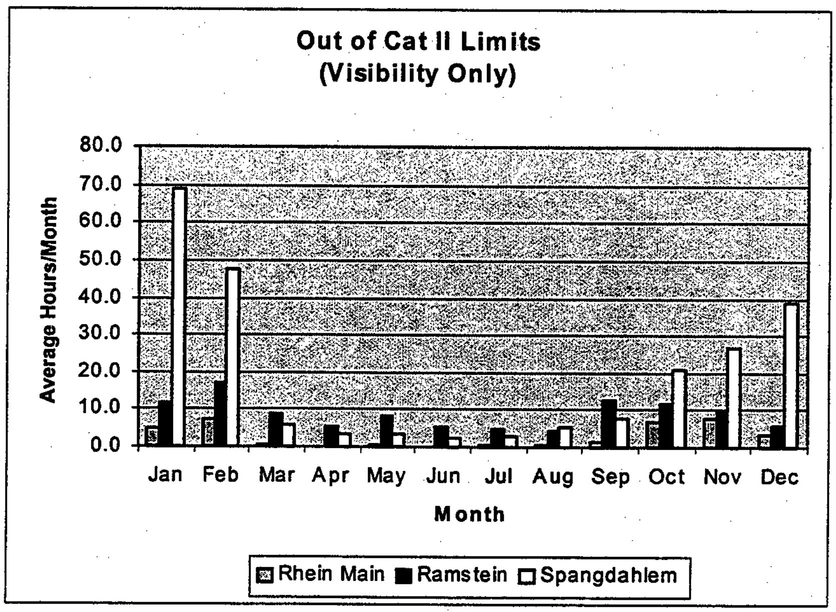

Figure 10. Out of Cat II Limits, Visibility Only

Cat IIIa

Figure 11 represents the average hourly occurrences that the visibility only was out of Cat IIIa limits for all the bases in question.

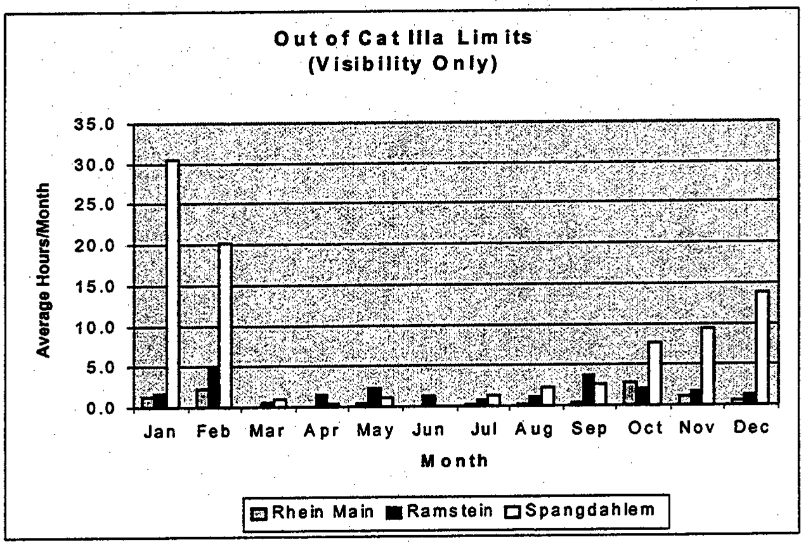

Figure 11. Out of Cat IIIa Limits, Visibility Only

Cat IIIb

Figure 12 represents the average hourly occurrences that the visibility only was out of Cat IIIb limits for all the bases in question.

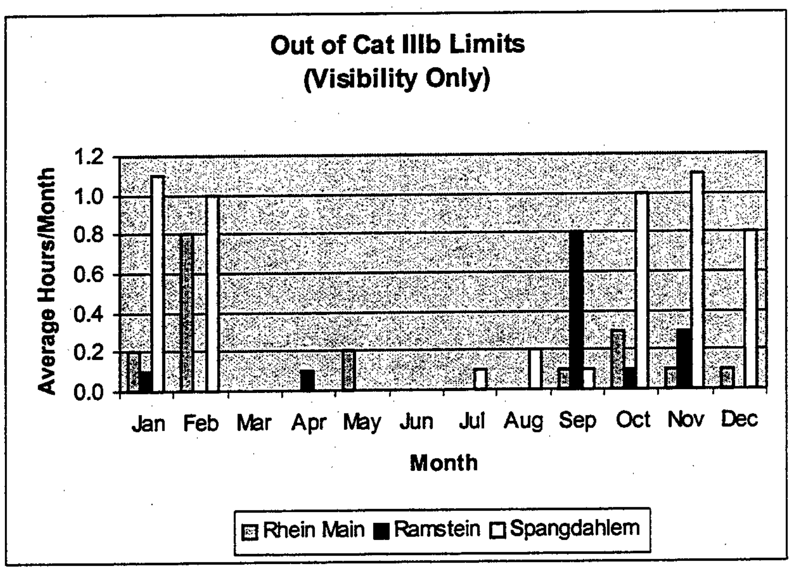

Figure 12. Out of Cat IIIb Limits, Visibility Only

Crosswinds

The crosswind data manipulation was based off of all the active runways of the bases in question. Table 13 shows the runway orientations as listed in the European FLIP Supplement.

Table 13, Runway Orientations (DOD FLIP Europe Supplement, B-126-7, B-284-5, B-331)

Base	Runway
Rhein Main AB	7L/R, 25L/R, 18
Ramstein AB	9, 27
Spangdahlem AB	5, 23

The crosswinds were figured using the runway orientation for each base. The maximum components that were calculated equate to different aircraft crosswind limitations. These limitations are summarized in Table 14. Table 14 is divided into two basic conditions, Dry and Runway Condition Readings (RCR). Certain airframes have individual RCR crosswind limits and others have range limits.

Table 14, Aircraft Crosswind Limits (Hardwick, 1999)

Crosswind Limits (Knots)												
		RCR										
Aircraft Type	Dry	0 to 5	6 to 8	> 8								
KC-135	25	No Ops	20	25								
WC-135	30	No Ops	20	30								
KC-10	30	No Ops	20	30								
C-17	30	13	21	25								
C-141	25	13	21	25								
		RCR										
	Dry	3	4	5	6	7	8	9	10	11	12	23
C-5	30	8	10	12	15	18	19	21	23			
C-9	30		5	7	10	12	15	17	20	22	30	
C-21	25				10	12	15	17	20	22	25	
C-130	35	2	5	7	10	12	15	17	20	22	25	35

To simplify the results, crosswind data is listed in basic categories. These include crosswinds greater than 20, 25, and 30 knots. These conditions equate to the dry limits of all Air Mobility Aircraft and to the majority of RCR conditions of the Strategic Airlift and Tanker aircraft. A RCR that would put an aircraft out of limits at crosswinds less than a 20 knots will not be considered. There is sufficient data available to draw conclusions about the crosswinds using winds greater than 20 knots. Note that this data represents crosswinds with a magnitude of either steady state or gusts, whichever is greater.

Finally, winds with a magnitude equal to or greater than 45 knots are included. This wind magnitude is not a crosswind, but reflects winds at this speed from any direction. This is included in the data to give an example of extreme weather conditions at each base that cause wind speeds which could preclude taxi or could cause damage to parked aircraft. It is included primarily for comparison purposes.

Rhein Main

Table 15. Rhein Main AB Crosswinds, Ten Year Totals

Rhein Main

Basic Crosswinds (10 Year Totals)

	> 20 Knots	> 25 Knots	> 30 Knots	> = 45 Knots (Non-Directional)	Out Of	Possible	%
Jan	12	3	2	4	7247	7440	0.9741
Feb	12	3	2	0	6577	6720	0.9787
Mar	33	11	0	1	7242	7440	0.9734
Apr	49	15	1	0	7051	7200	0.9793
May	14	2	1	0	7309	7440	0.9824
Jun	15	2	0	0	6937	7200	0.9635
Jul	7	3	0	0	6807	7440	0.9149
Aug	8	1	0	0	6863	7440	0.9224
Sep	3	2	1	1	6776	7200	0.9411
Oct	6	1	0	0	7238	7440	0.9728
Nov	3	0	0	0	6983	7200	0.9699
Dec	2	0	0	0	7060	7440	0.9489
Totals	**164**	**43**	**7**	**6**	**84090**	**87600**	**0.9599**

*No Crosswind duplicates of Ceiling and Vis

Table 15 shows the basic crosswind data for Rhein Main AB. This data is the total hourly occurrences over the ten-year period in question. Table 16 shows the ten-year hourly averages of Rhein Main crosswinds by month. Figure 13 is a graphical representation of Table 16.

Table 16. Rhein Main AB Average Hourly Crosswinds

Rhein Main Crosswinds (10 Year Average Hours/Month)	> 20 Knots	> 25 Knots	> 30 Knots	> = 45 Knots (Non-Directional)
Jan	1.2	0.3	0.2	0.4
Feb	1.2	0.3	0.2	0.0
Mar	3.3	1.1	0.0	0.1
Apr	4.9	1.5	0.1	0.0
May	1.4	0.2	0.1	0.0
Jun	1.5	0.2	0.0	0.0
Jul	0.7	0.3	0.0	0.0
Aug	0.8	0.1	0.0	0.0
Sep	0.3	0.2	0.1	0.1
Oct	0.6	0.1	0.0	0.0
Nov	0.3	0.0	0.0	0.0
Dec	0.2	0.0	0.0	0.0

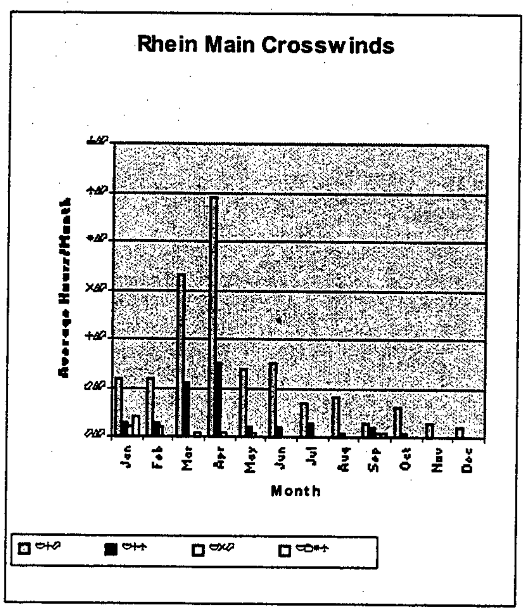

Figure 13. Rhein Main AB Average Hourly Crosswinds

Ramstein AB

Table 17 shows the basic crosswind data for Ramstein AB. This data is the total hourly occurrences over the ten-year period in question. Table 18 shows the ten-year hourly averages of Ramstein crosswinds by month. Figure 14 is a graphical representation of Table 18.

Table 17. Ramstein AB Crosswinds, Ten Year Totals

Ramstein

Basic Crosswinds (10 Year Totals)

	> 20 Knots	> 25 Knots	> 30 Knots	> = 45 Knots (Non-Directional)	Out Of	Possible	%
Jan	111	54	14	7	7374	7440	0.9911
Feb	48	17	3	3	6695	6720	0.9963
Mar	16	2	1	0	7375	7440	0.9913
Apr	15	3	0	0	7143	7200	0.9921
May	9	0	0	0	7334	7440	0.9858
Jun	10	2	1	0	7155	7200	0.9938
Jul	12	0	0	0	7403	7440	0.9950
Aug	13	2	0	0	7375	7440	0.9913
Sep	21	1	0	0	7138	7200	0.9914
Oct	8	0	0	0	7400	7440	0.9946
Nov	42	11	4	0	7129	7200	0.9901
Dec	38	12	0	0	7334	7440	0.9858
Totals	343	104	23	10	86855	87600	0.9915

*No Crosswind duplicates of Ceiling and Vis

Table 18. Ramstein AB Average Hourly Crosswinds

Ramstein

Crosswinds (10 Year Average Hours/Month)

	> 20 Knots	> 25 Knots	> 30 Knots	> = 45 Knots (Non-Directional)
Jan	11.1	5.4	1.4	0.7
Feb	4.8	1.7	0.3	0.3
Mar	1.6	0.2	0.1	0.0
Apr	1.5	0.3	0.0	0.0
May	0.9	0.0	0.0	0.0
Jun	1.0	0.2	0.1	0.0
Jul	1.2	0.0	0.0	0.0
Aug	1.3	0.2	0.0	0.0
Sep	2.1	0.1	0.0	0.0
Oct	0.8	0.0	0.0	0.0
Nov	4.2	1.1	0.4	0.0
Dec	3.8	1.2	0.0	0.0

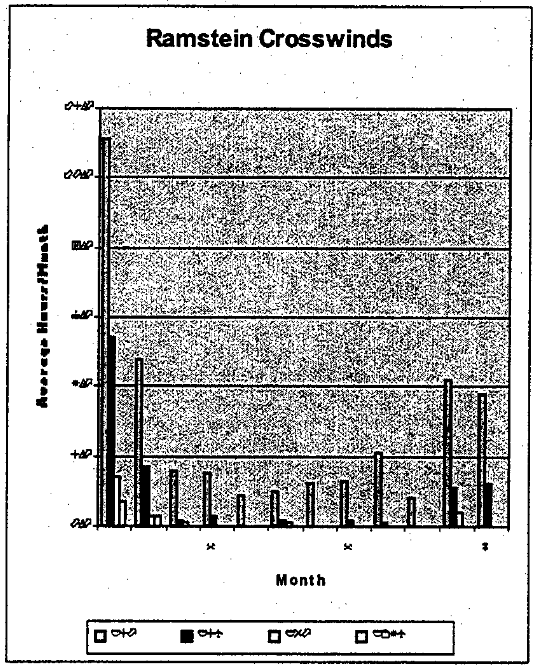

Figure 14. Ramstein AB Average Hourly Crosswinds

Spangdahlem AB

Table 19 shows the basic crosswind data for Ramstein AB. This data is the total hourly occurrences over the ten-year period in question. Table 20 shows the ten-year hourly averages of Ramstein crosswinds by month. Figure 15 is a graphical representation of Table 20.

Table 19. Spangdahlem AB Crosswinds, Ten Year Totals

Spangdahlem
Basic Crosswinds (10 Year Totals)

	> 20 Knots	> 25 Knots	> 30 Knots	> = 45 Knots (Non-Directional)	Out Of	Possible	%
Jan	74	39	19	9	7213	7440	0.9695
Feb	111	52	24	6	6718	6720	0.9997
Mar	68	26	7	3	7390	7440	0.9933
Apr	48	4	0	0	7122	7200	0.9892
May	17	4	0	0	7266	7440	0.9766
Jun	1	11	0	0	7055	7200	0.9799
Jul	12	1	1	0	7315	7440	0.9832
Aug	11	0	0	0	7385	7440	0.9926
Sep	24	8	1	0	6943	7200	0.9643
Oct	13	1	0	0	7390	7440	0.9933
Nov	27	9	3	0	6784	7200	0.9422
Dec	34	17	5	0	6715	7440	0.9026
Totals	**440**	**172**	**60**	**18**	**85296**	**87600**	**0.9737**

*One 20 Knot occurrence in Jan and Mar that coincides with Cat I Ceiling and Vis limitations

Table 20. Spangdahlem AB, Average Hourly Crosswinds

Spangdahlem
Crosswinds (Average Hours/Month)

	> 20 Knots	> 25 Knots	> 30 Knots	> = 45 Knots (Non-Directional)
Jan	7.4	3.9	1.9	0.9
Feb	11.1	5.2	2.4	0.6
Mar	6.8	2.6	0.7	0.3
Apr	4.8	0.4	0.0	0.0
May	1.7	0.4	0.0	0.0
Jun	0.1	1.1	0.0	0.0
Jul	1.2	0.1	0.1	0.0
Aug	1.1	0.0	0.0	0.0
Sep	2.4	0.8	0.1	0.0
Oct	1.3	0.1	0.0	0.0
Nov	2.7	0.9	0.3	0.0
Dec	3.4	1.7	0.5	0.0

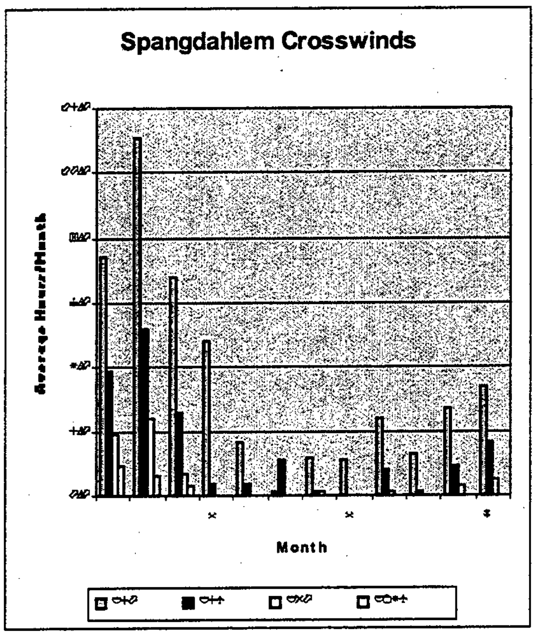

Figure 15. Spangdahlem AB Average Hourly Crosswinds

Crosswind Comparisons

The following four figures compare each wind magnitude with the different locations. Figures 16 – 18 show the crosswinds greater than 20, 25 and 30 knots, respectively in average hourly occurrences per month. Figure 19 shows the average

hourly occurrence of 45 knot winds or greater per month. Remember that the 45 knot wind figure is not a crosswind; it is a magnitude and could be from any direction. This figure is provided for extreme weather comparisons and will be discussed further in Chapter IV.

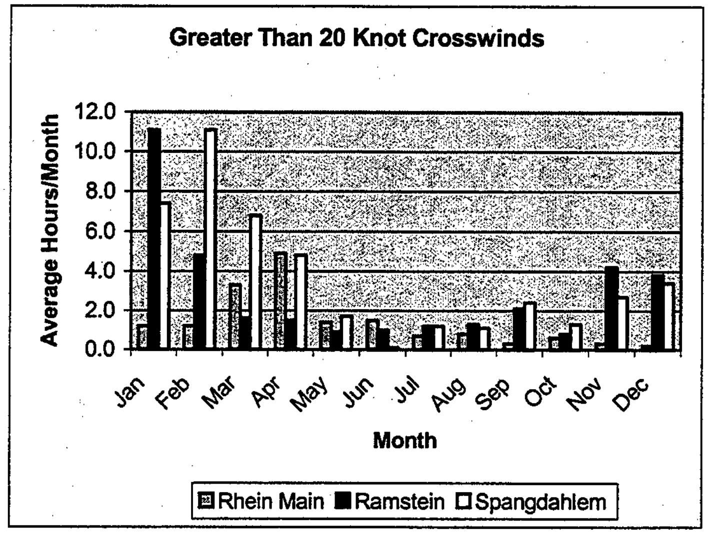

Figure 16. Average Hourly Crosswind Greater than 20 Knots

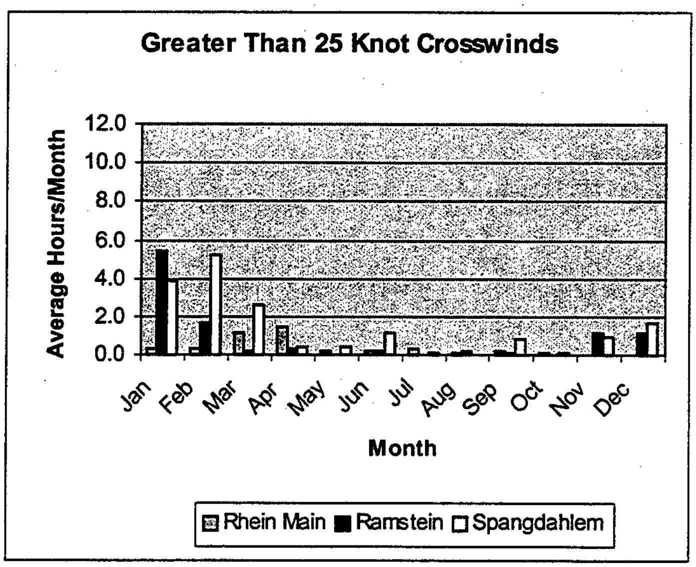

Figure 17. Average Hourly Crosswind Greater than 25 Knots

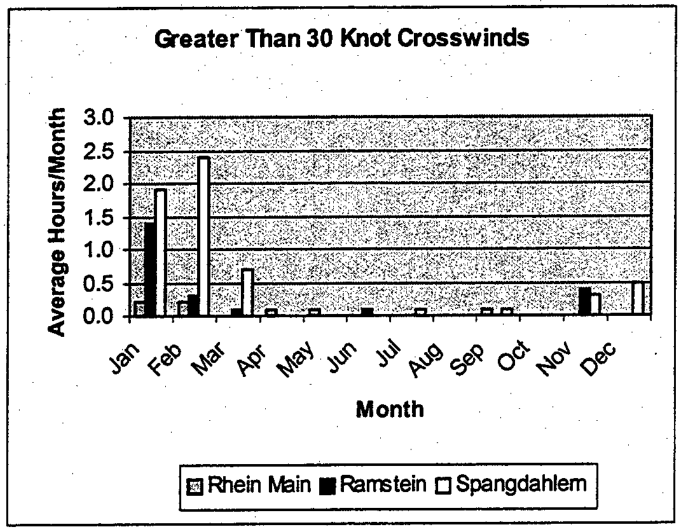

Figure 18. Average Hourly Crosswind Greater than 30 Knots

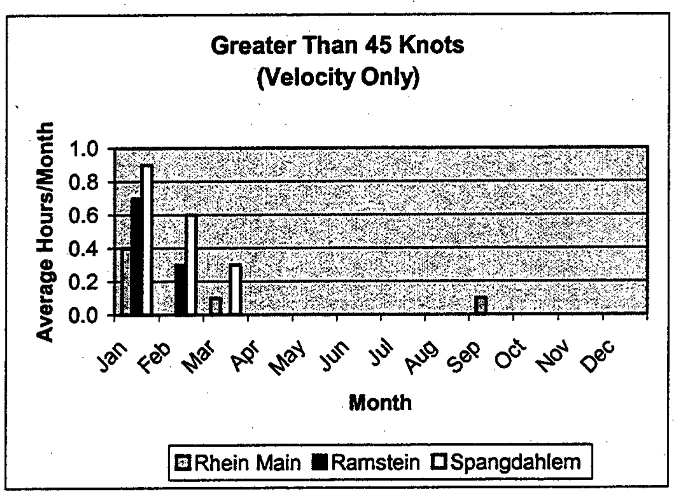

Figure 19. Average Hourly Wind Equal to or Greater Than 45 Knots

Ceiling & Vis

The most important data in this report for USAFE is the combination of ceiling and visibility for the purpose of determining category limits. USAFE requires both ceiling and visibility, as opposed to AMC requirements. The unit of measurement is still in hourly occurrences per month. Both ten-year totals and averages are provided. The data reflects occurrences that weather is out of the category limits.

This section shows data divided into two general groups. The first group includes uncorrected additions of each occurrence of ceiling and visibility. They are for each base and in that particular weather category. For example, Table 4 shows that there were 83 Cat II ceiling only occurrences in January. From Table 8 you can take the average Cat II occurrences of 4.7, multiply that by 10 to come up with 47. These add together to equal 130, reference Table 21, Uncorrected Cat II for Jan.

The uncorrected data is flawed. A corrected version was calculated and all 256,489 data entries were compared to see when both the ceiling and visibility were out of category limits on the same hour. These duplicates were then subtracted from the totals so that an occurrence of ceiling and visibility on the same hour was not double counted. By doing this, a more accurate result is achieved for the average hourly occurrences of weather out of the corresponding category limits.

Rhein Main

Table 21 shows the ten-year totals for both uncorrected and corrected occurrences of hours that weather was out of Cat I and Cat II limits for Rhein Main AB.

Table 22 shows the average values of the same data in Table 21. Figure 20 and 21 are graphical representations of the uncorrected and corrected sections in Table 22.

Table 21. Rhein Main AB Ceiling and Visibility, Ten Year Totals

Rhein Main Ceiling & Visibility (10 Year Totals)	Uncorrected Cat II	 Cat I	Corrected Cat II	 Cat I
Jan	130	302	95	192
Feb	200	330	140	213
Mar	17	38	15	28
Apr	4	16	4	12
May	9	19	5	11
Jun	7	14	5	8
Jul	10	18	5	10
Aug	3	14	1	9
Sep	29	53	18	32
Oct	161	286	107	177
Nov	209	441	150	272
Dec	88	255	65	168

Table 22. Rhein Main AB Ceiling and Visibility, Ten Year Averages

Rhein Main Ceiling & Visibility (Average Hours/Month)	Uncorrected Cat II	 Cat I	Corrected Cat II	 Cat I
Jan	13.0	30.2	9.5	19.2
Feb	20.0	33.0	14.0	21.3
Mar	1.7	3.8	1.5	2.8
Apr	0.4	1.6	0.4	1.2
May	0.9	1.9	0.5	1.1
Jun	0.7	1.4	0.5	0.8
Jul	1.0	1.8	0.5	1.0
Aug	0.3	1.4	0.1	0.9
Sep	2.9	5.3	1.8	3.2
Oct	16.1	28.6	10.7	17.7
Nov	20.9	44.1	15.0	27.2
Dec	8.8	25.5	6.5	16.8

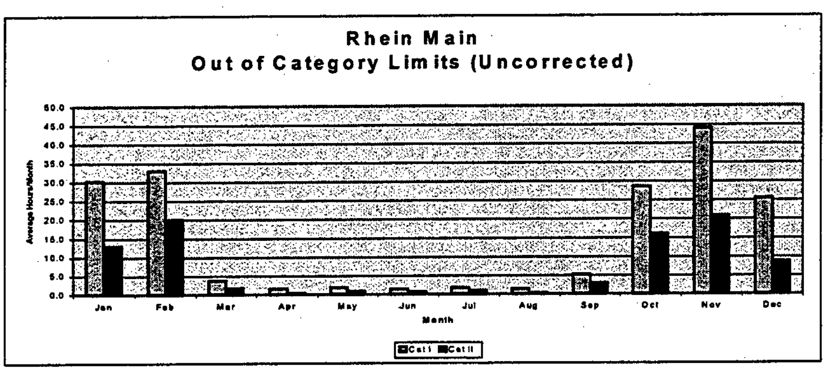

Figure 20. Rhein Main AB Ceiling and Visibility, Uncorrected Hourly Averages

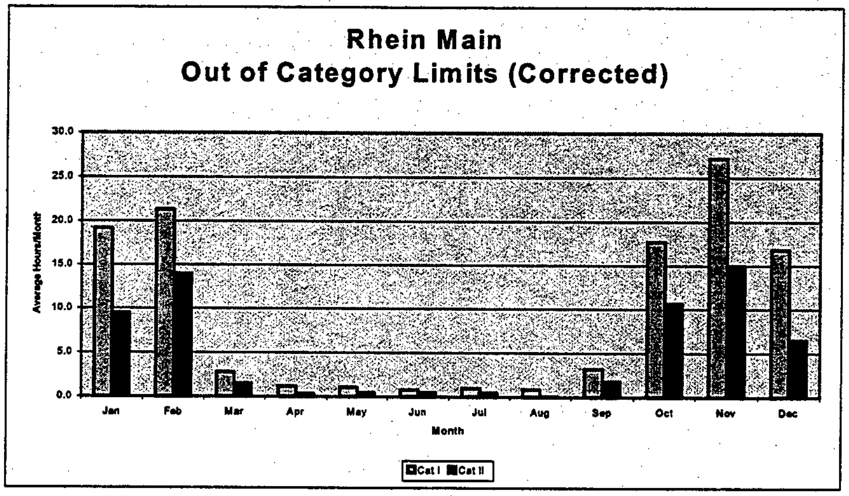

Figure 21. Rhein Main AB Ceiling and Visibility, Corrected Hourly Averages

Ramstein

Table 23 shows the ten-year totals for both uncorrected and corrected occurrences of hours that weather was out of Cat I and Cat II limits for Ramstein AB. Table 24 shows the average values of the same data in Table 23. Figure 22 and 23 are graphical representations of the uncorrected and corrected sections in Table 24.

Table 23. Ramstein, Ceiling and Visibility, Ten Year Totals

Ramstein

Ceiling & Visibility (10 Year Totals)

	Uncorrected		Corrected	
	Cat II	Cat I	Cat II	Cat I
Jan	164	345	158	284
Feb	198	413	188	313
Mar	124	201	108	148
Apr	72	114	66	100
May	118	171	96	143
Jun	61	102	59	92
Jul	64	88	58	72
Aug	57	115	49	91
Sep	178	296	147	228
Oct	249	437	170	237
Nov	144	299	125	174
Dec	104	196	88	84

Table 24. Ramstein AB Ceiling and Visibility, Ten Year Averages

Ramstein	Ceiling & Visibility (Average Hours/Month)			
	Uncorrected		Corrected	
	Cat II	Cat I	Cat II	Cat I
Jan	16.4	34.5	15.8	28.4
Feb	19.8	41.3	18.8	31.3
Mar	12.4	20.1	10.8	14.8
Apr	7.2	11.4	6.6	10.0
May	11.8	17.1	9.6	14.3
Jun	6.1	10.2	5.9	9.2
Jul	6.4	8.8	5.8	7.2
Aug	5.7	11.5	4.9	9.1
Sep	17.8	29.6	14.7	22.8
Oct	24.9	43.7	17.0	23.7
Nov	14.4	29.9	12.5	17.4
Dec	10.4	19.6	8.8	8.4

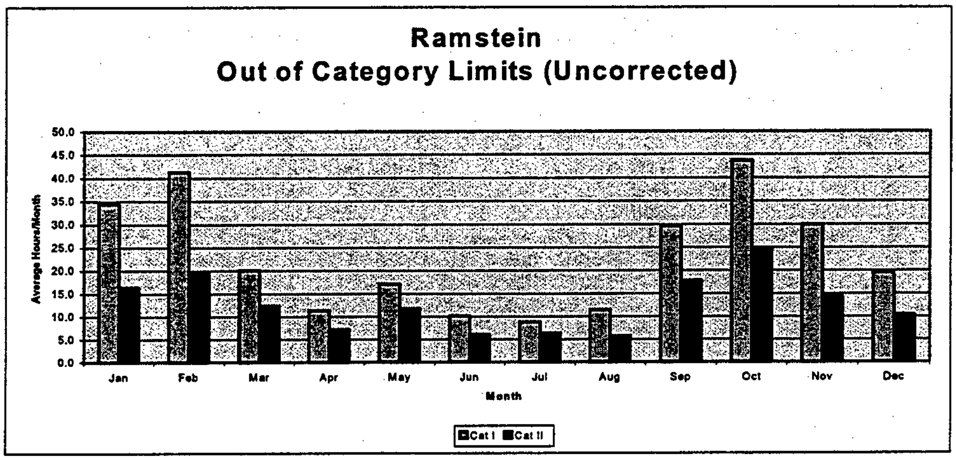

Figure 22. Ramstein AB Ceiling and Visibility, Uncorrected Hourly Averages

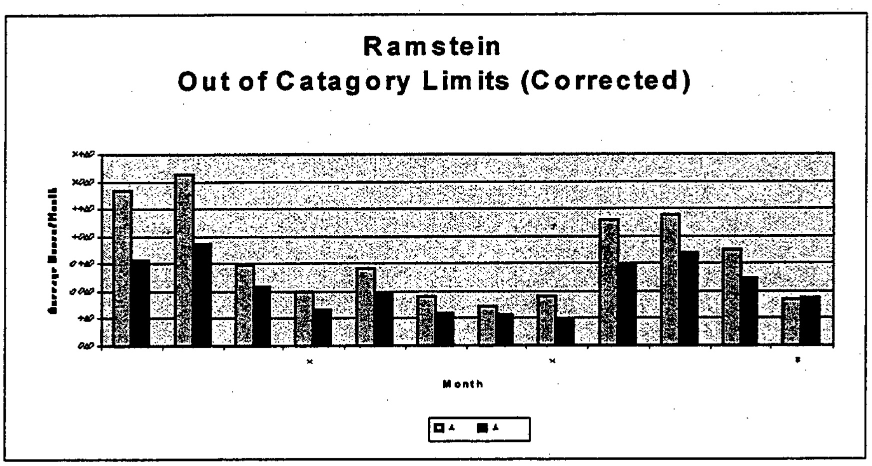

Figure 23. Ramstein AB Ceiling and Visibility, Corrected Hourly Averages

Spangdahlem AB

Table 25 shows the ten-year totals for both uncorrected and corrected occurrences of hours that weather was out of Cat I and Cat II limits at Spangdahlem AB. Table 26 shows the average values of the same data in Table 25. Figure 24 and 25 are graphical representations of the uncorrected and corrected sections in Table 26.

Table 25, Spangdahlem AB, Ceiling and Visibility, Ten Year Totals

Spangdahlem
Ceiling & Visibility (10 Year Totals)

	Uncorrected		Corrected	
	Cat II	Cat I	Cat II	Cat I
Jan	829	1735	703	990
Feb	525	1065	475	711
Mar	76	193	63	140
Apr	38	90	34	67
May	40	71	36	53
Jun	38	64	30	44
Jul	45	69	39	52
Aug	62	108	54	78
Sep	100	183	87	129
Oct	278	480	221	335
Nov	340	765	282	501
Dec	452	1091	393	697

Table 26, Spangdahlem AB, Ceiling and Visibility, Ten Year Averages

Spangdahlem
Ceiling & Visibility (Average Hours/Month)

	Uncorrected		Corrected	
	Cat II	Cat I	Cat II	Cat I
Jan	82.9	173.5	70.3	99.0
Feb	52.5	106.5	47.5	71.1
Mar	7.6	19.3	6.3	14.0
Apr	3.8	9.0	3.4	6.7
May	4.0	7.1	3.6	5.3
Jun	3.8	6.4	3.0	4.4
Jul	4.5	6.9	3.9	5.2
Aug	6.2	10.8	5.4	7.8
Sep	10.0	18.3	8.7	12.9
Oct	27.8	48.0	22.1	33.5
Nov	34.0	76.5	28.2	50.1
Dec	45.2	109.1	39.3	69.7

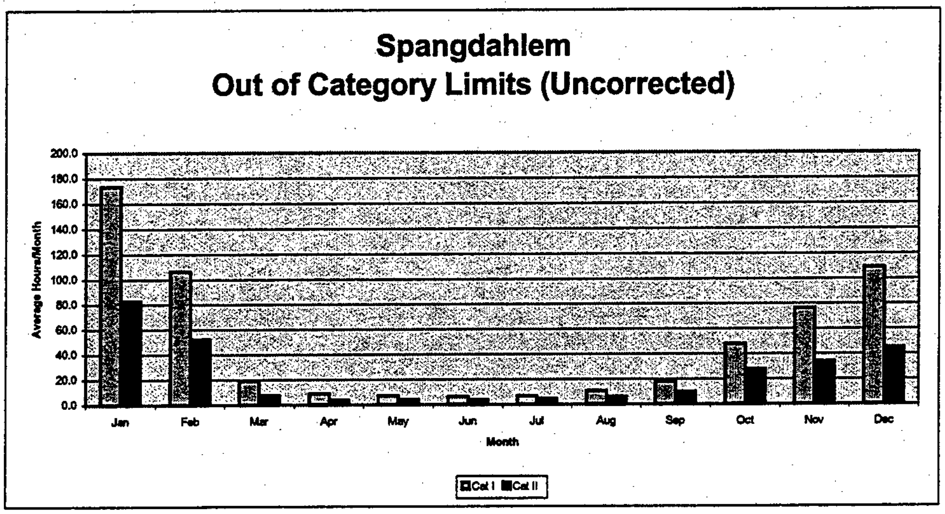

Figure 24. Spangdahlem AB Ceiling and Visibility, Uncorrected Hourly Averages

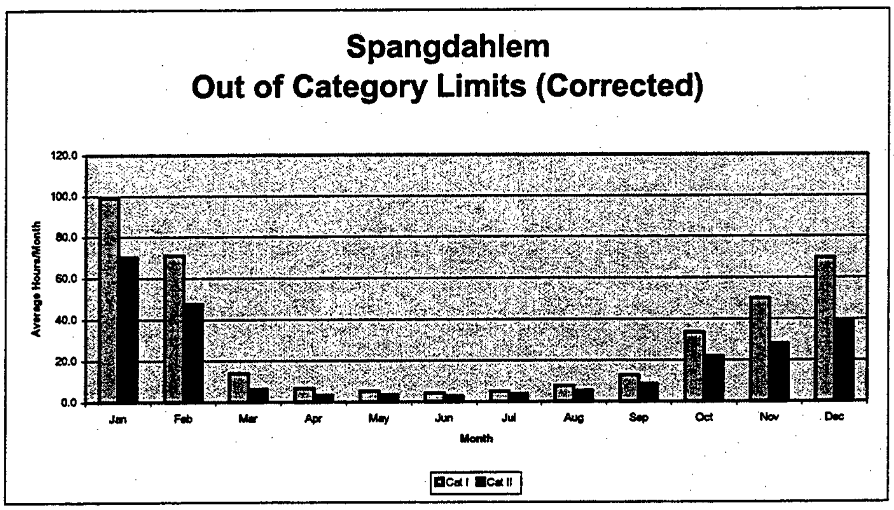

Figure 25. Spangdahlem AB Ceiling and Visibility, Corrected Hourly Averages

Cat I and Cat II Comparisons by Base

Figures 26 and 27 show the comparison of the uncorrected data for out of Category I and II limits respectively, using average hourly occurrences each month for each base.

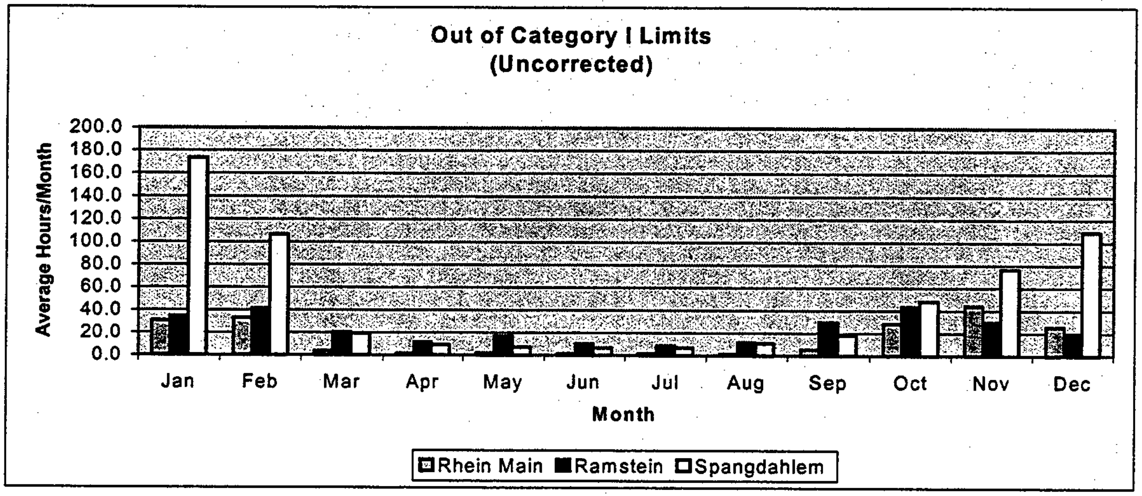

Figure 26. Out Of Category I Limits, Uncorrected

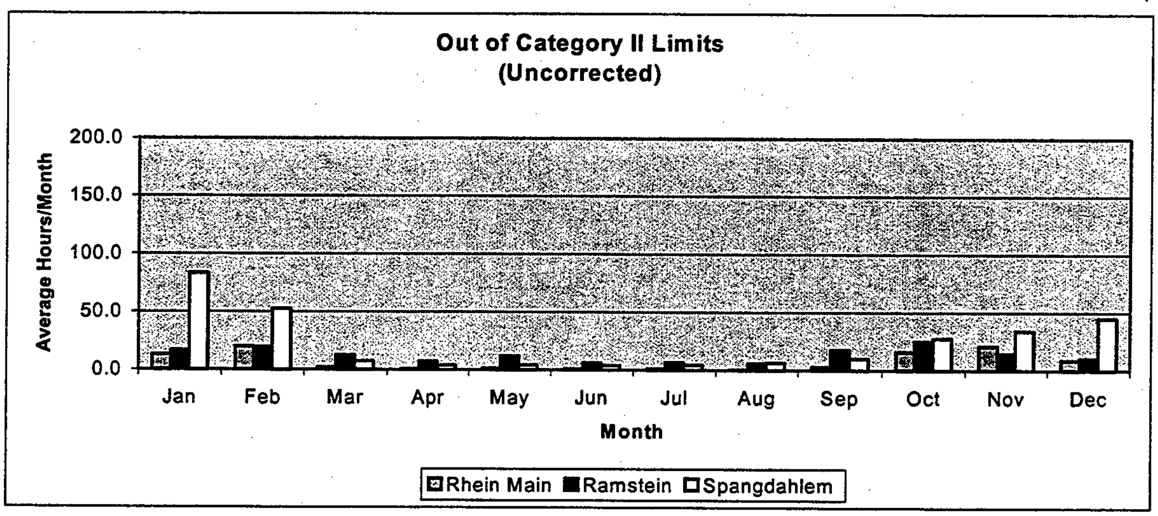

Figure 27. Out Of Category II Limits, Uncorrected

Figures 28 and 29 show the comparison of the corrected data for out of Category I and II limits respectively, using average hourly occurrences each month for each base. These figures are some of the most important in this paper. They will be discussed in detail in the following chapter.

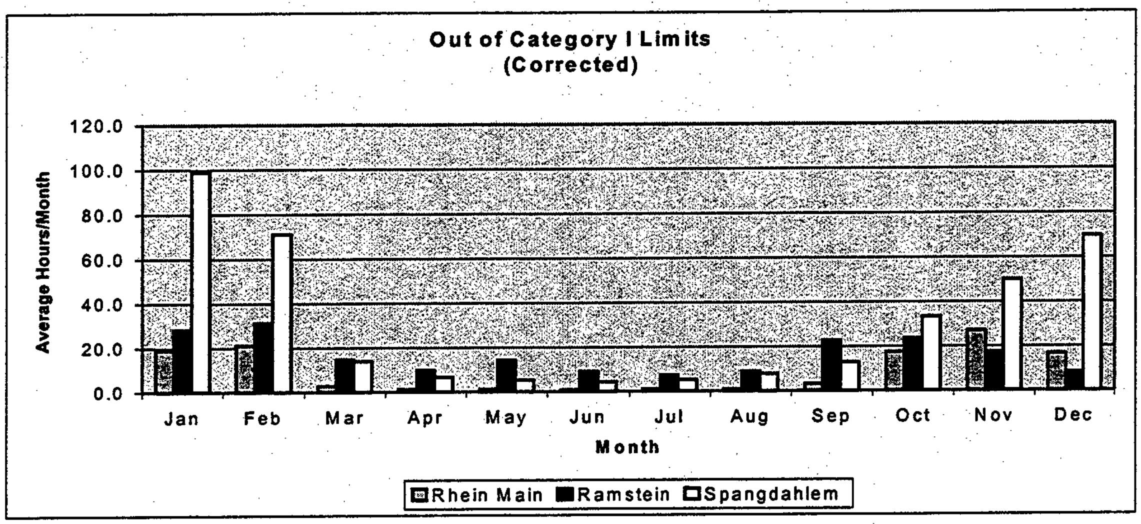

Figure 28. Out Of Category I Limits, Corrected

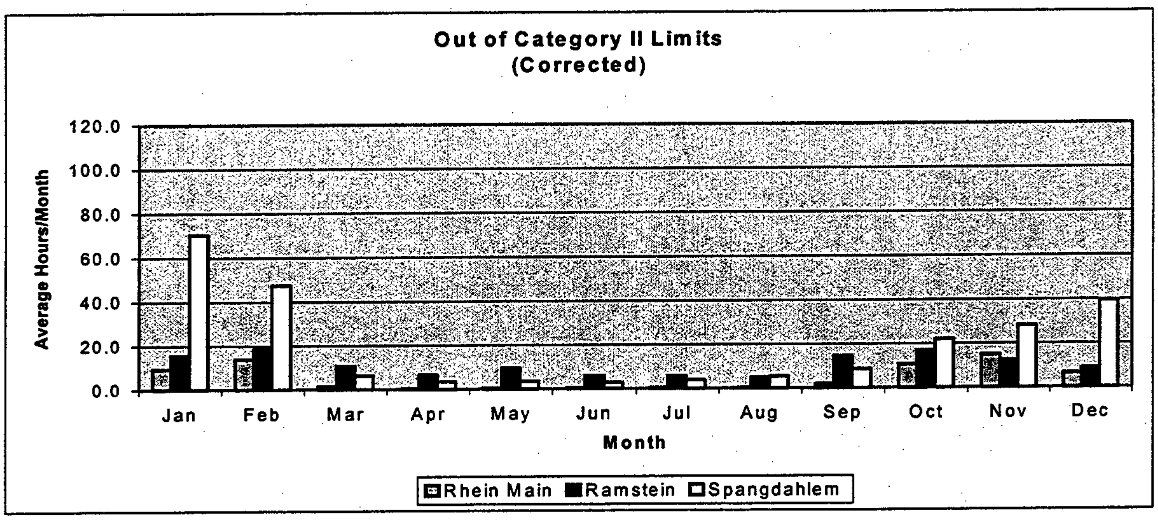

Figure 29. Out Of Category II Limits, Corrected

Data Summary

This data is the result of hourly weather observations from Rhein Main, Ramstein, and Spangdahlem AB for 1989 through 1998. This will be analyzed in the next chapter.

IV. Analysis

Background

Chapter III laid out a rash of data in four main categories. These included the following: ceiling, visibility, crosswinds, and ceiling and visibility combined. This chapter will compare and contrast the results of chapter III in the same order. Chapter V will then introduce the concept of throughput to these results.

One important note is that Air Mobility Command (AMC) and United States Air Forces Europe (USAFE) place different requirements on the weather minima. For example, USAFE requires ceiling and visibility minima for shooting an approach while AMC only requires ceiling. This is the primary reason ceiling and visibility data was split up and then combined into a separate section. These results will serve both theater leaders.

Ceiling

The first observation from the ceiling data reveals that the majority of bad weather for all bases occurs in and between the months of October through February (Ref Figures 1 – 3). For the rest of this discussion, these months will be termed the "weather months".

Because extra data was included in the tables and figures, the reader needs to look closely at the data that is most important. This data is the weather that makes Cat I or Cat II landings impossible. Thus, the importance of Figures 4 and 5 is seen, which

shows the average monthly hours each base is out of the respective category limits. Cat I rejection is thus defined as the instances weather is out of that category limit. The same is true for Cat II rejection. Note also that this section deals only with ceiling.

The worst base for Cat I rejections is Spangdahlem. The worst months, from Table 6 and Figure 4, are January (80.2 hours), December (46.4 hours), February (37 hours), November (31.9 hours) and October (17.3 hours). Ramstein and Rhein Main have less dramatic results and in four of the five poor weather months, Rhein Main actually has worse Cat I rejection than Ramstein (Reference Figure 4).

Cat II rejections are a mix of results and three of the five weather months do not include Spangdahlem. This is significant only to point out that Spangdahlem does not, for ceiling purposes, have claim to the majority of Cat II rejections.

Although the weather months suggest that ceiling is a factor for transiting aircraft, data suggests that this is not so. Table 27 shows the relative impact of Cat I and Cat II rejection in the percent of time per month.

Table 27. Percent of Month in Cat I and Cat II Rejection (M = Month)

Month	Rhein Main				Ramstein				Spangdahlem			
	Cat I		Cat II		Cat I		Cat II		Cat I		Cat II	
	hr/M	**% of M**	hr/M	% of M	hr/M	**% of M**	hr/M	% of M	hr/M	**% of M**	hr/M	% of M
Jan	17.6	2.37%	8.3	1.12%	10.8	1.45%	4.8	0.65%	80.2	10.78%	14.1	1.90%
Feb	19.6	2.92%	12.7	1.89%	11.8	1.76%	2.9	0.43%	37.0	5.51%	5.2	0.77%
Mar	2.1	0.28%	1.2	0.16%	5.7	0.77%	3.5	0.47%	6.8	0.91%	2.0	0.27%
Apr	0.9	0.13%	0.2	0.03%	2.9	0.40%	1.8	0.25%	2.8	0.39%	0.5	0.07%
May	1.0	0.13%	0.4	0.05%	3.8	0.51%	3.7	0.50%	1.9	0.26%	0.6	0.08%
Jun	0.8	0.11%	0.5	0.07%	1.4	0.19%	1.0	0.14%	2.2	0.31%	1.5	0.21%
Jul	0.9	0.12%	0.5	0.07%	2.0	0.27%	1.4	0.19%	2.2	0.30%	1.7	0.23%
Aug	0.7	0.09%	0.3	0.04%	3.0	0.40%	1.4	0.19%	3.3	0.44%	1.0	0.13%
Sep	2.7	0.38%	1.6	0.22%	7.6	1.06%	5.3	0.74%	5.4	0.75%	2.0	0.28%
Oct	15.4	2.07%	9.2	1.24%	23.1	3.10%	13.2	1.77%	17.3	2.33%	7.1	0.95%
Nov	25.6	3.56%	13.2	1.83%	14.7	2.04%	4.8	0.67%	31.9	4.43%	7.2	1.00%
Dec	14.2	1.91%	5.6	0.75%	6.2	0.83%	4.5	0.60%	46.4	6.24%	6.6	0.89%

Table 27 shows the data of hours per month, repeated from Tables 4 – 6, and then figures the percent of the time for each month that the base suffers Cat I and II rejection. For example,10.78% of the Month of Jan, Spangdahlem AB suffers Cat I rejection. To illustrate how these percents compare to the total time that ceiling is not a factor, see Figure 30.

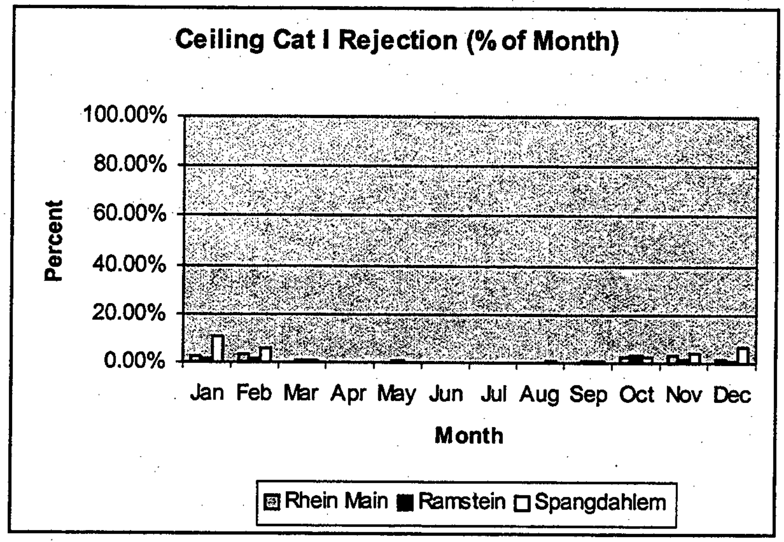

Figure 30. Ceiling Cat I Rejection in % per Month

Figure 30 is scaled to 100 percent to show the reader that the Cat I rejection in comparison to the availability of the bases in question is less of the problem than originally believed. Cat II rejection is even less as the highest percent was 1.9, thus a figure was not created.

In conclusion of this section on ceiling, Spangdahlem has the majority of Cat I rejections while Ramstein has the majority of Cat II rejections. This being the case, the overall impact of poor ceilings at the bases in question is less of a limitation to aircraft than previously believed.

Visibility

The visibility section is somewhat more complicated as Cat III rejections are addressed. For the purpose of this paper, Cat III calculations are primarily dependent on visibility. This is so because the data collected and reported by the AFCCC does not include the increment of a 50-foot ceiling. The use of Cat III requirements are further limited, as stated earlier, due to the fact that 50-meter visibility was not recorded as well.

The key figures to this section on visibility are Figures 10 – 13. These show the occurrences of Cat I, Cat II, and Cat III rejections due to visibility only. Similar to the last section on ceiling analysis, Tables 28 – 30 show the percent of each month that each base has Cat I, II, IIIa, and IIIb rejection.

Table 28. Rhein Main AB Percent of Month in Category Rejection

Rhein Main								
Month	Cat I hr/M	% of M	Cat II hr/M	% of M	Cat IIIa hr/M	% of M	Cat IIIb hr/M	% of M
Jan	12.6	1.69%	4.7	0.63%	1.3	0.17%	0.2	0.03%
Feb	13.4	1.99%	7.3	1.09%	2.2	0.33%	0.8	0.12%
Mar	1.7	0.23%	0.5	0.07%	0.0	0.00%	0.0	0.00%
Apr	0.7	0.10%	0.2	0.03%	0.0	0.00%	0.0	0.00%
May	0.9	0.12%	0.5	0.07%	0.4	0.05%	0.2	0.03%
Jun	0.6	0.08%	0.2	0.03%	0.0	0.00%	0.0	0.00%
Jul	0.9	0.12%	0.5	0.07%	0.1	0.01%	0.0	0.00%
Aug	0.7	0.09%	0.3	0.04%	0.1	0.01%	0.0	0.00%
Sep	2.6	0.36%	1.3	0.18%	0.3	0.04%	0.1	0.01%
Oct	13.2	1.77%	6.9	0.93%	2.8	0.38%	0.3	0.04%
Nov	18.5	2.57%	7.7	1.07%	1.2	0.17%	0.1	0.01%
Dec	11.3	1.52%	3.2	0.43%	0.6	0.08%	0.1	0.01%

Table 29. Ramstein AB Percent of Month in Category Rejection

Ramstein								
Month	Cat I hr/M	% of M	Cat II hr/M	% of M	Cat IIIa hr/M	% of M	Cat IIIb hr/M	% of M
Jan	23.7	3.19%	11.6	1.56%	1.6	0.22%	0.1	0.01%
Feb	29.5	4.39%	16.9	2.51%	5.0	0.74%	0.0	0.00%
Mar	14.4	1.94%	8.9	1.20%	0.6	0.08%	0.0	0.00%
Apr	8.5	1.18%	5.4	0.75%	1.5	0.21%	0.1	0.01%
May	13.3	1.79%	8.1	1.09%	2.2	0.30%	0.0	0.00%
Jun	8.8	1.22%	5.1	0.71%	1.3	0.18%	0.0	0.00%
Jul	6.8	0.91%	5.0	0.67%	0.8	0.11%	0.0	0.00%
Aug	8.5	1.14%	4.3	0.58%	1.1	0.15%	0.0	0.00%
Sep	22.0	3.06%	12.5	1.74%	3.7	0.51%	0.8	0.11%
Oct	20.6	2.77%	11.7	1.57%	2.0	0.27%	0.1	0.01%
Nov	15.2	2.11%	9.6	1.33%	1.6	0.22%	0.3	0.04%
Dec	13.4	1.80%	5.9	0.79%	1.3	0.17%	0.0	0.00%

Table 30. Spangdahlem AB Percent of Month in Category Rejection

Spangdahlem								
Month	Cat I hr/M	% of M	Cat II hr/M	% of M	Cat IIIa hr/M	% of M	Cat IIIb hr/M	% of M
Jan	93.3	12.54%	68.8	9.25%	30.6	4.11%	1.1	0.15%
Feb	69.5	10.34%	47.3	7.04%	20.2	3.01%	1.0	0.15%
Mar	12.5	1.68%	5.6	0.75%	1.0	0.13%	0.0	0.00%
Apr	6.2	0.86%	3.3	0.46%	0.4	0.06%	0.0	0.00%
May	5.2	0.70%	3.4	0.46%	1.2	0.16%	0.0	0.00%
Jun	4.2	0.58%	2.3	0.32%	0.0	0.00%	0.0	0.00%
Jul	4.7	0.63%	2.8	0.38%	1.3	0.17%	0.1	0.01%
Aug	7.5	1.01%	5.2	0.70%	2.3	0.31%	0.2	0.03%
Sep	12.9	1.79%	8.0	1.11%	2.6	0.36%	0.1	0.01%
Oct	30.7	4.13%	20.7	2.78%	7.7	1.03%	1.0	0.13%
Nov	44.6	6.19%	26.8	3.72%	9.3	1.29%	1.1	0.15%
Dec	62.7	8.43%	38.6	5.19%	13.8	1.85%	0.8	0.11%

Tables 28 – 30 show that the category limitations on aircraft arrival are not as great in comparison to the entire month. To better illustrate this point, Figure 31 shows

a graphical comparison of all the bases as the percent of the month visibility causes Cat I rejection.

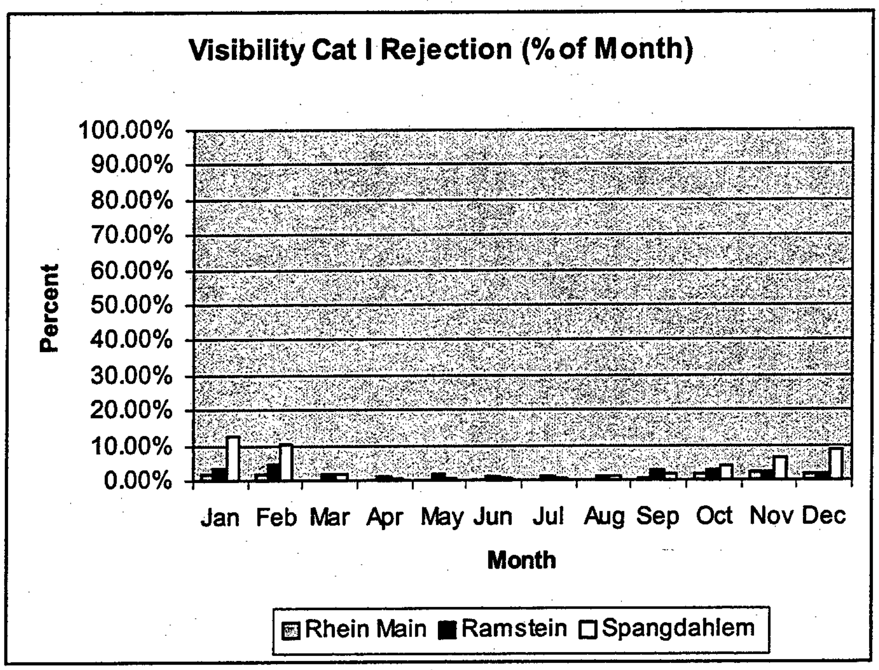

Figure 31. Visibility Cat I Rejection in % per Month

Cat II, IIIa, and IIIb figures are not shown, but Tables 28 –30 clearly show that the results are the same. All of the percentages for those categories are less than those of Cat I.

The influence of poor visibility has an effect on Category rejection. Spangdahlem AB is the clear winner of the poor visibility award. For the worst month of January, Spangdahlem can still receive, on average, 87.45% of all flight activity compared to 96.81% for Ramstein and 98.31% for Rhein Main. Although Rhein Main has significantly better visibility, Ramstein can accomplish 98.47% (96.81/98.31) and Spangdahlem can accomplish 88.8% (87.45/98.31) of the capability of Rhein Main, using the example of January. This aspect will be further investigated in Chapter V.

Crosswinds

The results of the crosswind analysis are somewhat different than the preceding sections as Category Rejection does not come into play. In the case of crosswinds, the crosswind component for all active runways was calculated and the magnitudes compared with each other. The crosswind comparisons, Figures 16 – 18, give the majority of the results. It is important to note that there were no occurrences of out of crosswind limits that coincided with conditions resulting in out of category limits for Rhein Main or Ramstein. There were only two out of 440 hours in the ten year period of data where crosswinds were greater than 20 knots and at the same time out of Cat I limits for ceiling and or visibility. Thus, it is safe to say that crosswinds are independent of category conditions.

The idea that strong winds are not related to category rejection conditions is also intuitive as poor visibility and low ceilings are indicative of fog or low pressure systems. Wind is usually present at higher magnitudes when convective heating is allowed to take place. Low ceilings prevent the ground from warming, thus inhibiting the creation of updrafts, which equate to a decrease in stronger winds.

This discussion on the independence of crosswinds from category rejection is significant as it allows another area for the comparison of the bases in question. The occurrences of category rejection can therefore be added to the occurrences of out of crosswind limits. However, the reader will have to take this data for each aircraft type to come up with individual totals.

Tables 31-33 illustrate the relative impact of winds as compared to the percent of monthly occurrence. These tables give the average occurrences of each type of wind condition and then equate it to the percent of an entire month that these conditions are present which would inhibit the operation of various aircraft platforms. In addition, the occurrence of 45-knot or greater wind magnitude is also an indicator of the occurrences of extreme weather conditions compared between the bases in question.

Table 31. Rhein Main AB Wind Condition (% of Month)

Rhein Main								
	Crosswinds						**Magnitude**	
Month	> 20 Knots		> 25 Knots		> 30 Knots		> = 45 Knots	
	hr/M	**% of M**	hr/M	**% of M**	hr/M	**% of M**	hr/M	**% of M**
Jan	1.2	0.16%	0.3	0.04%	0.2	0.03%	0.4	0.05%
Feb	1.2	0.18%	0.3	0.04%	0.2	0.03%	0.0	0.00%
Mar	3.3	0.44%	1.1	0.15%	0.0	0.00%	0.1	0.01%
Apr	4.9	0.68%	1.5	0.21%	0.1	0.01%	0.0	0.00%
May	1.4	0.19%	0.2	0.03%	0.1	0.01%	0.0	0.00%
Jun	1.5	0.21%	0.2	0.03%	0.0	0.00%	0.0	0.00%
Jul	0.7	0.09%	0.3	0.04%	0.0	0.00%	0.0	0.00%
Aug	0.8	0.11%	0.1	0.01%	0.0	0.00%	0.0	0.00%
Sep	0.3	0.04%	0.2	0.03%	0.1	0.01%	0.1	0.01%
Oct	0.6	0.08%	0.1	0.01%	0.0	0.00%	0.0	0.00%
Nov	0.3	0.04%	0.0	0.00%	0.0	0.00%	0.0	0.00%
Dec	0.2	0.03%	0.0	0.00%	0.0	0.00%	0.0	0.00%

Table 32. Ramstein AB Wind Condition (% of Month)

Ramstein								
	Crosswinds						**Magnitude**	
Month	> 20 Knots		> 25 Knots		> 30 Knots		> = 45 Knots	
	hr/M	**% of M**	hr/M	**% of M**	hr/M	**% of M**	hr/M	**% of M**
Jan	11.1	1.49%	5.4	0.73%	1.4	0.19%	0.7	0.09%
Feb	4.8	0.71%	1.7	0.25%	0.3	0.04%	0.3	0.04%
Mar	1.6	0.22%	0.2	0.03%	0.1	0.01%	0.0	0.00%
Apr	1.5	0.21%	0.3	0.04%	0.0	0.00%	0.0	0.00%
May	0.9	0.12%	0.0	0.00%	0.0	0.00%	0.0	0.00%
Jun	1.0	0.14%	0.2	0.03%	0.1	0.01%	0.0	0.00%
Jul	1.2	0.16%	0.0	0.00%	0.0	0.00%	0.0	0.00%
Aug	1.3	0.17%	0.2	0.03%	0.0	0.00%	0.0	0.00%
Sep	2.1	0.29%	0.1	0.01%	0.0	0.00%	0.0	0.00%
Oct	0.8	0.11%	0.0	0.00%	0.0	0.00%	0.0	0.00%
Nov	4.2	0.58%	1.1	0.15%	0.4	0.06%	0.0	0.00%
Dec	3.8	0.51%	1.2	0.16%	0.0	0.00%	0.0	0.00%

Table 33. Spangdahlem AB Wind Condition (% of Month)

Spangdahlem								
	Crosswinds						**Magnitude**	
Month	> 20 Knots		> 25 Knots		> 30 Knots		> = 45 Knots	
	hr/M	**% of M**	hr/M	**% of M**	hr/M	**% of M**	hr/M	**% of M**
Jan	7.4	0.99%	3.9	0.52%	1.9	0.26%	0.9	0.12%
Feb	11.1	1.65%	5.2	0.77%	2.4	0.36%	0.6	0.09%
Mar	6.8	0.91%	2.6	0.35%	0.7	0.09%	0.3	0.04%
Apr	4.8	0.67%	0.4	0.06%	0.0	0.00%	0.0	0.00%
May	1.7	0.23%	0.4	0.05%	0.0	0.00%	0.0	0.00%
Jun	0.1	0.01%	1.1	0.15%	0.0	0.00%	0.0	0.00%
Jul	1.2	0.16%	0.1	0.01%	0.1	0.01%	0.0	0.00%
Aug	1.1	0.15%	0.0	0.00%	0.0	0.00%	0.0	0.00%
Sep	2.4	0.33%	0.8	0.11%	0.1	0.01%	0.0	0.00%
Oct	1.3	0.17%	0.1	0.01%	0.0	0.00%	0.0	0.00%
Nov	2.7	0.38%	0.9	0.13%	0.3	0.04%	0.0	0.00%
Dec	3.4	0.46%	1.7	0.23%	0.5	0.07%	0.0	0.00%

Figure 32 is a combination of the greater than twenty-knot column for Table 31 – 33. The scale of Figure 32 shows a better comparison between the different bases. Both

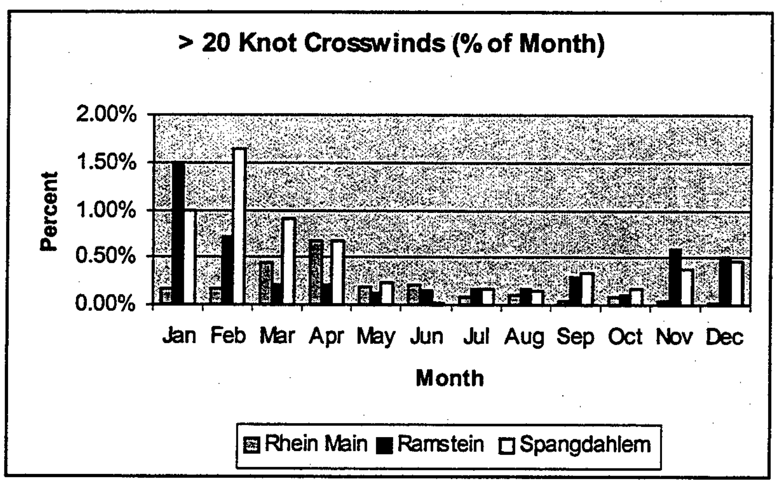

Figure 32. Greater Than 20 Knot Crosswinds in % per Month (Small Scale)

Ramstein and Spangdahlem have worse 20-knot crosswinds compared to Rhein Main. However, Figure 33 shows the overall impact of these kinds of winds on operations at

these bases. For example, the worst frequency of 20-knot winds occurs in February at Spangdahlem and accounts for 1.65% of the month. Thus, 98.35% of the time, Spangdahlem has crosswinds that are less than or equal to 20 knots. From this

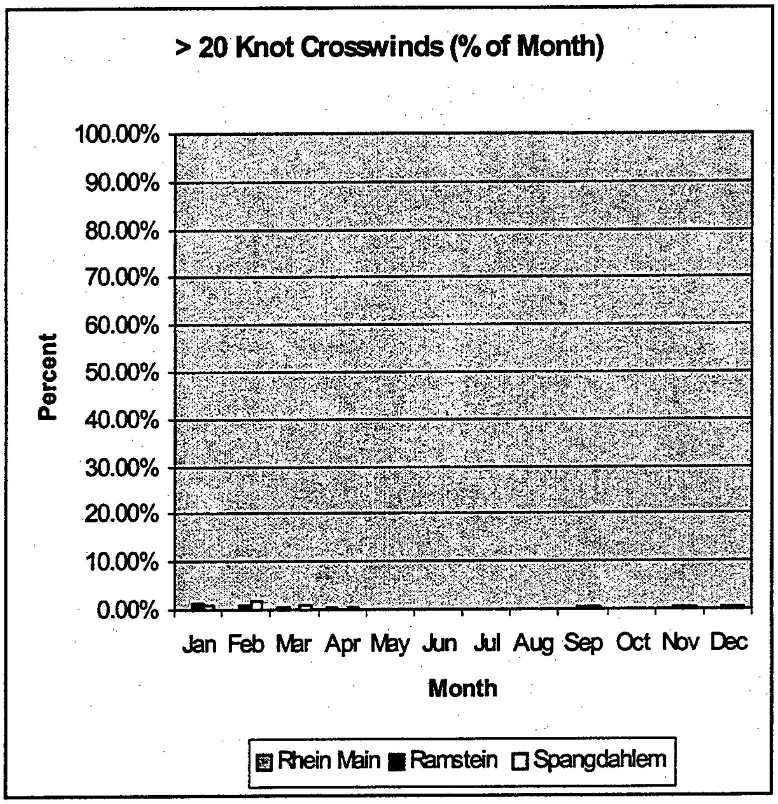

Figure 33. Greater Than 20 Knot Crosswinds in % per Month (Large Scale)

perspective, crosswinds do not limit operations at Spangdahlem and Ramstein even if they have twice as many out of crosswind conditions as Rhein Main.

Additional figures will not be produced for 25, 30 and 45 knot winds as these conditions have even less occurrences. Also, remember that the out-of-crosswind conditions must be added to the Category Rejection data to come up with an overall table. This will be done in the next chapter.

Ceiling and Visibility

This section is specifically for USAFE because they require both ceiling and visibility minimums in order to commence an approach. This requirement of both ceiling and visibility is also critical for AMC in the event mobility aircraft come under the operational control of USAFE. An example of this is the KC-135s that Change Operational Control (CHOP) to USAFE when TDY as part of the European Tanker Task Force. Although tanker aircraft are not normally used when calculating throughput, they are used as a backup asset as they were for Operation Desert Storm. C-17's are under Tactical Control (TACON) of USAFE for Operation Noble Anvil and Shining Hope but still follow AMC criterion.

The focus of the analysis will be on the corrected results. Table 34 shows the percent of each month the combined ceiling and visibility is out of each respective category minimums.

Table 34. Ceiling and Visibility in Percent of Monthly Category Rejection (Corrected)

Ceiling and Visibility (Corrected)												
	Rhein Main				Ramstein				Spangdahlem			
Month	Cat I		Cat II		Cat I		Cat II		Cat I		Cat II	
	hr/M	% of M	hr/M	% of M	hr/M	% of M	hr/M	% of M	hr/M	% of M	hr/M	% of M
Jan	19.2	2.58%	9.5	1.28%	28.4	3.82%	15.8	2.12%	99.0	13.31%	70.3	9.45%
Feb	21.3	3.17%	14.0	2.08%	31.3	4.66%	18.8	2.80%	71.1	10.58%	47.5	7.07%
Mar	2.8	0.38%	1.5	0.20%	14.8	1.99%	10.8	1.45%	14.0	1.88%	6.3	0.85%
Apr	1.2	0.17%	0.4	0.06%	10.0	1.39%	6.6	0.92%	6.7	0.93%	3.4	0.47%
May	1.1	0.15%	0.5	0.07%	14.3	1.92%	9.6	1.29%	5.3	0.71%	3.6	0.48%
Jun	0.8	0.11%	0.5	0.07%	9.2	1.28%	5.9	0.82%	4.4	0.61%	3.0	0.42%
Jul	1.0	0.13%	0.5	0.07%	7.2	0.97%	5.8	0.78%	5.2	0.70%	3.9	0.52%
Aug	0.9	0.12%	0.1	0.01%	9.1	1.22%	4.9	0.66%	7.8	1.05%	5.4	0.73%
Sep	3.2	0.44%	1.8	0.25%	22.8	3.17%	14.7	2.04%	12.9	1.79%	8.7	1.21%
Oct	17.7	2.38%	10.7	1.44%	23.7	3.19%	17.0	2.28%	33.5	4.50%	22.1	2.97%
Nov	27.2	3.78%	15.0	2.08%	17.4	2.42%	12.5	1.74%	50.1	6.96%	28.2	3.92%
Dec	16.8	2.26%	6.5	0.87%	8.4	1.13%	8.8	1.18%	69.7	9.37%	39.3	5.28%

Figures 34 and 35 are a graphical representation of the Category I Rejection data from Table 34. The difference between these two figures is only the scale. The different scales are used to illustrate the differences between the bases (Figure 34) and then show the relationship of category rejection to the month in total (Figure 35).

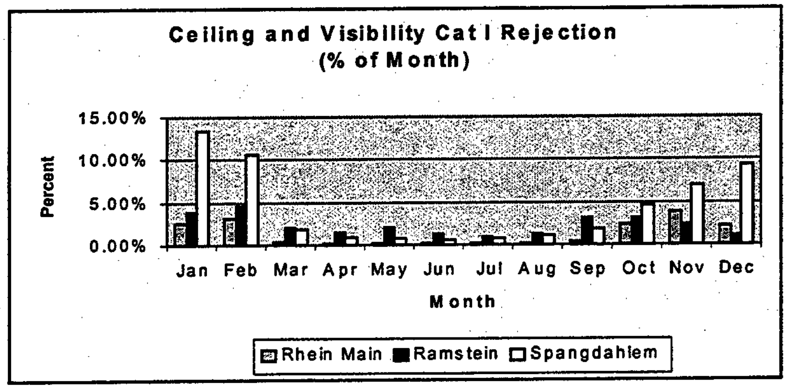

Figure 34. Ceiling and Visibility Cat I Rejection in % per Month (Small Scale)

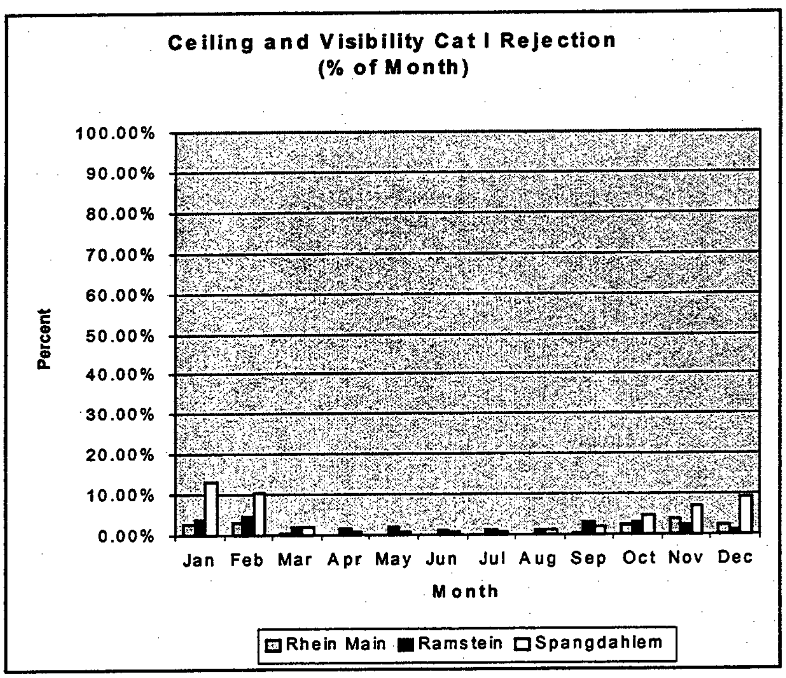

Figure 35. Ceiling and Visibility Cat I Rejection in % per Month (Large Scale)

Figures 36 and 37 are a graphical representation of the Category II Rejection data from Table 34. Similar to Figures 34 and 35, these two figures show different scales to illustrate the differences between the bases (Figure 36) and then show the relationship of category rejection to the month in total (Figure 37).

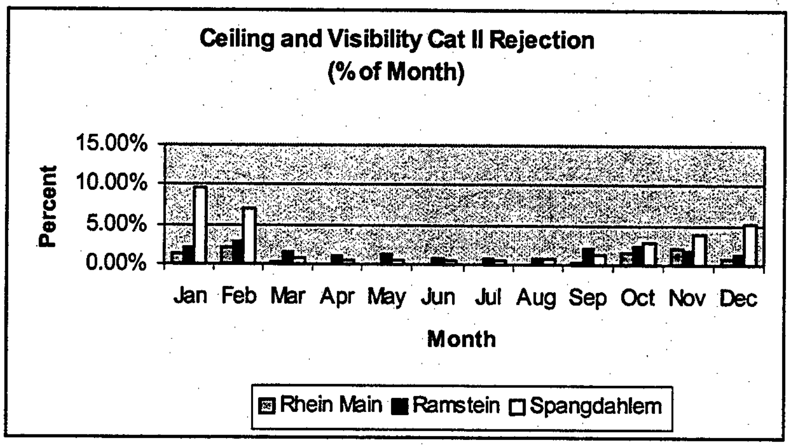

Figure 36. Ceiling and Visibility Cat II Rejection in % per Month (Small Scale)

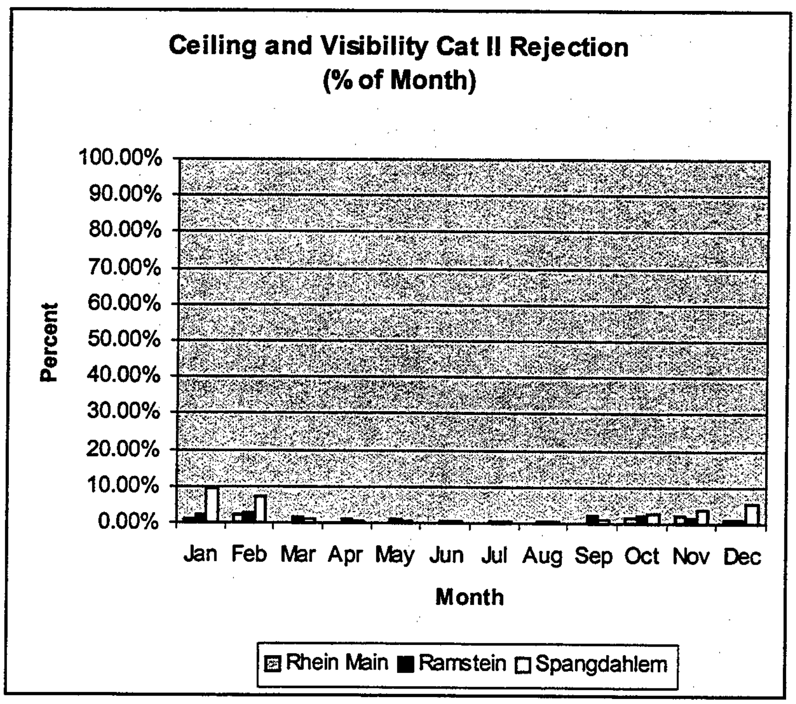

Figure 37. Ceiling and Visibility Cat II Rejection in % per Month (Large Scale)

The occurrences of ceiling and visibility that cause category rejection are not just an addition of the ceiling occurrences and then the visibility occurrences. The raw data was searched and corrected for duplicate entries that would have made a particular hour fall into category rejection. This point has been made already, but it is repeated due to its importance.

The ceiling and visibility section shows that Spangdahlem AB is by far the worst of the three bases. The worst month is Cat I rejection for January. This is 13.31% of the month for Spangdahlem compared to 3.82% for Ramstein AB and 2.58% for Rhein Main AB. Thus, for January, Spangdahlem AB operates at 88.99% and Ramstein AB at 98.73% the capacity of Rhein Main AB for weather in Category I limits.

Summary

The fact that Spangdahlem AB has the worst weather is now substantiated with data that backs up this statement. Ramstein AB also has worse weather than Rhein Main AB. The point to remember is that although Spangdahlem AB and Ramstein AB have worse weather than Rhein Main, they still can be effective the vast majority of the time. The percent of monthly occurrences for out-of-weather limitations for each of ceiling, visibility, crosswind, and ceiling and visibility is the result that will be used in the next section on throughput.

V. Weather Constrained Throughput

Introduction

If you are able to determine the percentage of the time a base is available for use under different weather conditions, then you can apply known throughput for each base to determine the number of personnel and amount of supplies can transit any particular base. This concept is what the author has coined as "weather constrained throughput". In other words, the average time weather limits the arrival of mobility assets has a direct affect on the amount of people and logistical supplies that can also arrive at the base in question.

AMC and USAFE put together a Capability Analysis in Oct 1998. This study compared the capability of Rhein Main AB as compared to that of Ramstein AB and Spangdahlem. The synopsis of the study cautions against "examining only the simple physical capabilities Rhein Main provides" (HQ USAFE, p. 4). The report goes on to say that "pure physical capabilities alone do not provide effective and efficient operations" and that "factors such as personnel, commercial contract availability, geographic location, weather, transportation and communications links, tenant support, etc. are intangibles that must be considered" (HQ USAFE, p. 4). It is this intangible weather that must be figured into the equation for planners to use when developing any type of Contingency (CONPLAN) or Operational Plan (OPLAN).

The 1998 Capabilities Analysis provides throughput data. However, it is unclear if this data has been corrected for the occurrence of out of category weather or crosswind limits. This chapter will meld the results of the weather data of this paper with the

throughput capacities derived from the plan of action for the current configuration of Rhein Main AB and the proposed infrastructure upgrades of Ramstein AB and Spangdahlem AB by the year 2005.

Unconstrained Throughput

The data in Table 35 is a summary of the 1998 Capabilities Analysis. This data has only been calculated for C-5, C-17, and Contract Carrier aircraft as these airframes will be the bulk of all strategic airlift.

Table 35. Basic Throughput Per Day (USAFE, p. 25)

Base	C-5			C-17			Commercial			Totals		
	Pax	Cargo	A/C	Pax	Cargo	A/C	Pax	Cargo	A/C	Pax	Cargo	A/C
Rhein Main	3066	2574.6	42	0	8640	192	4800	0	12	7866	11215	246
Ramstein PIK I	3942	3310.2	54	0	4680	104	0	0	0	3942	7990.2	158
Current Totals	**7008**	**5884.8**	**96**	**0**	**13320**	**296**	**4800**	**0**	**12**	**11808**	**19205**	**404**
Ramstein	5694	4781.4	78	0	5760	128	4800	0	12	10494	10541	218
Spangdahlem	7884	6620.4	108	0	0	0	0	0	0	7884	6620.4	108
2005 Totals	**13578**	**11402**	**186**	**0**	**5760**	**128**	**4800**	**0**	**12**	**18378**	**17162**	**326**
* Cargo in Short Tons												

This table brings to mind the main basis of the comparison. The capability of Rhein Main and Ramstein as a function of Payment-In-Kind I (PIK I) is the benchmark for the future upgrades at Ramstein and Spangdahlem in the year 2005. PIK I was the partial return of Rhein Main to the FAG in return for 100 Million DM ($57.1 M) in payment in kind or the funding of added infrastructure at Ramstein (Motz, 1999). The final return of Rhein Main AB to the FAG will produce an additional group of funded projects (PIK II) which the 2005 totals reflect in Table 35. The idea is to get equal capability with the Spangdahlem-Ramstein combination as was with the Rhein Main-

Ramstein combination. The numbers are close, but in some cases reflect decreased capability as shown in Table 36.

Table 36. Capability Comparison (USAFE, p. 5)

	CURRENT CAPABILITIES			USAFE PROPOSAL			% of Existing
	Rhein Main*	Ramstein*	Total	Ramstein	Spangdahlem	Total	Capacity
Sorties/Day	123	79	202	109	54	163	81%
# Fuel Hydrants	15	22	37	31	18	49	132%
Pump Capacity	3600	7200	10800	7200	3600	10800	100%
Parking Spots	33	22	55	31	18	49	89%
Cargo (Ston/Day)	5607.3	3995.1	9602.4	5270.7	3310.2	8580.9	89%
Passengers/Day	16000	8000	24000	16000	4000	20000	83%
Passengers/Day **	7866	3942	11808	10494	7884	18378	156%

* Based off of PIK I funded projects completed
** From Table 37

The data in Table 36 is somewhat confusing. The author added the second passengers/day row to reflect the data in Table 35. The assumption is that the first passengers/day row is a maximum capacity of the bases in question. Also, note that additional information in regards to infrastructure is included in Table 36. This is to show the reader that maximums need to be planned for in determining the basic fuel needs and parking.

Weather will cause constraints on the ability of aircraft to land and this will directly affect the cargo and passengers per day shown in Table 36. Thus, the point of this paper is that weather needs to be included when figuring out the throughput of cargo and passengers. The corrected flows are more complicated than just planning for the maximum. The following section will apply the data calculations of this report and yield a final definitive table of throughput capabilities.

Constrained Throughput

The following group of tables summarize the entire effort in this paper to come up with percentages of operating capability based off of monthly weather phenomena and the effect that weather has on the ability of aircraft to land. Tables 37 – 45 are the summarized percent of category rejections for each crosswind condition subtracted from one. In other words, the occurrences of out of limit winds are added into the category rejections for each weather condition measured and subtracted from one to yield a total percent of the month that operations can occur within that category limit.

For Example, Table 37 shows the percentages of each month that crosswinds are less than or equal to 20 knots and within the respective category limit. Note that Tables 37 –45 do not include 45 knot wind data as they were only provided for Chapter IV analysis.

Table 37. Rhein Main Throughput Capacity, < = 20 Knot Crosswind (% per Month)

Rhein Main Throughput Capability (% per Month) < = 20 Kt Crosswind								
Month	Ceiling		Visibility				Ceiling & Visibility	
	Cat I	Cat II	Cat I	Cat II	Cat IIIa	Cat IIIb	Cat I	Cat II
Jan	97.47%	98.72%	98.15%	99.21%	99.66%	99.81%	97.26%	98.56%
Feb	96.90%	97.93%	97.83%	98.74%	99.49%	99.70%	96.65%	97.74%
Mar	99.27%	99.40%	99.33%	99.49%	99.56%	99.56%	99.18%	99.35%
Apr	99.19%	99.29%	99.22%	99.29%	99.32%	99.32%	99.15%	99.26%
May	99.68%	99.76%	99.69%	99.74%	99.76%	99.78%	99.66%	99.74%
Jun	99.68%	99.72%	99.71%	99.76%	99.79%	99.79%	99.68%	99.72%
Jul	99.78%	99.84%	99.78%	99.84%	99.89%	99.91%	99.77%	99.84%
Aug	99.80%	99.85%	99.80%	99.85%	99.88%	99.89%	99.77%	99.88%
Sep	99.58%	99.74%	99.60%	99.78%	99.92%	99.94%	99.51%	99.71%
Oct	97.85%	98.68%	98.15%	98.99%	99.54%	99.88%	97.54%	98.48%
Nov	96.40%	98.13%	97.39%	98.89%	99.79%	99.94%	96.18%	97.88%
Dec	98.06%	99.22%	98.45%	99.54%	99.89%	99.96%	97.72%	99.10%

Table 38. Rhein Main Throughput Capacity, < = 25 Knot Crosswind (% per Month)

Rhein Main Throughput Capability (% per Month)
< = 25 Kt Crosswind

Month	Ceiling		Visibility				Ceiling & Visibility	
	Cat I	Cat II	Cat I	Cat II	Cat IIIa	Cat IIIb	Cat I	Cat II
Jan	97.59%	98.84%	98.27%	99.33%	99.78%	99.93%	97.38%	98.68%
Feb	97.04%	98.07%	97.96%	98.87%	99.63%	99.84%	96.79%	97.87%
Mar	99.57%	99.69%	99.62%	99.78%	99.85%	99.85%	99.48%	99.65%
Apr	99.67%	99.76%	99.69%	99.76%	99.79%	99.79%	99.63%	99.74%
May	99.84%	99.92%	99.85%	99.91%	99.92%	99.95%	99.83%	99.91%
Jun	99.86%	99.90%	99.89%	99.94%	99.97%	99.97%	99.86%	99.90%
Jul	99.84%	99.89%	99.84%	99.89%	99.95%	99.96%	99.83%	99.89%
Aug	99.89%	99.95%	99.89%	99.95%	99.97%	99.99%	99.87%	99.97%
Sep	99.60%	99.75%	99.61%	99.79%	99.93%	99.96%	99.53%	99.72%
Oct	97.92%	98.75%	98.21%	99.06%	99.61%	99.95%	97.61%	98.55%
Nov	96.44%	98.17%	97.43%	98.93%	99.83%	99.99%	96.22%	97.92%
Dec	98.09%	99.25%	98.48%	99.57%	99.92%	99.99%	97.74%	99.13%

Table 39. Rhein Main Throughput Capacity, < = 30 Knot Crosswind (% per Month)

Rhein Main Throughput Capability (% per Month)
< = 30 Kt Crosswind

Month	Ceiling		Visibility				Ceiling & Visibility	
	Cat I	Cat II	Cat I	Cat II	Cat IIIa	Cat IIIb	Cat I	Cat II
Jan	97.61%	98.86%	98.28%	99.34%	99.80%	99.95%	97.39%	98.70%
Feb	97.05%	98.08%	97.98%	98.88%	99.64%	99.85%	96.80%	97.89%
Mar	99.72%	99.84%	99.77%	99.93%	100.00%	100.00%	99.62%	99.80%
Apr	99.86%	99.96%	99.89%	99.96%	99.99%	99.99%	99.82%	99.93%
May	99.85%	99.93%	99.87%	99.92%	99.93%	99.96%	99.84%	99.92%
Jun	99.89%	99.93%	99.92%	99.97%	100.00%	100.00%	99.89%	99.93%
Jul	99.88%	99.93%	99.88%	99.93%	99.99%	100.00%	99.87%	99.93%
Aug	99.91%	99.96%	99.91%	99.96%	99.99%	100.00%	99.88%	99.99%
Sep	99.61%	99.76%	99.63%	99.81%	99.94%	99.97%	99.54%	99.74%
Oct	97.93%	98.76%	98.23%	99.07%	99.62%	99.96%	97.62%	98.56%
Nov	96.44%	98.17%	97.43%	98.93%	99.83%	99.99%	96.22%	97.92%
Dec	98.09%	99.25%	98.48%	99.57%	99.92%	99.99%	97.74%	99.13%

Table 40. Ramstein Throughput Capacity, < = 20 Knot Crosswind (% per Month)

Ramstein Throughput Capability (% per Month)
< = 20 Kt Crosswind

Month	Ceiling		Visibility				Ceiling & Visibility	
	Cat I	Cat II	Cat I	Cat II	Cat IIIa	Cat IIIb	Cat I	Cat II
Jan	97.06%	97.86%	95.32%	96.95%	98.29%	98.49%	94.69%	96.38%
Feb	97.53%	98.85%	94.90%	96.77%	98.54%	99.29%	94.63%	96.49%
Mar	99.02%	99.31%	97.85%	98.59%	99.70%	99.78%	97.80%	98.33%
Apr	99.39%	99.54%	98.61%	99.04%	99.58%	99.78%	98.40%	98.88%
May	99.37%	99.38%	98.09%	98.79%	99.58%	99.88%	97.96%	98.59%
Jun	99.67%	99.72%	98.64%	99.15%	99.68%	99.86%	98.58%	99.04%
Jul	99.57%	99.65%	98.92%	99.17%	99.73%	99.84%	98.87%	99.06%
Aug	99.42%	99.64%	98.68%	99.25%	99.68%	99.83%	98.60%	99.17%
Sep	98.65%	98.97%	96.65%	97.97%	99.19%	99.60%	96.54%	97.67%
Oct	96.79%	98.12%	97.12%	98.32%	99.62%	99.88%	96.71%	97.61%
Nov	97.38%	98.75%	97.31%	98.08%	99.19%	99.38%	97.00%	97.68%
Dec	98.66%	98.88%	97.69%	98.70%	99.31%	99.49%	98.36%	98.31%

Table 41. Ramstein Throughput Capacity, < = 25 Knots (% per Month)

Ramstein Throughput Capability (% per Month) < = 25 Kt Crosswind								
Month	Ceiling		Visibility				Ceiling & Visibility	
	Cat I	Cat II	Cat I	Cat II	Cat IIIa	Cat IIIb	Cat I	Cat II
Jan	97.82%	98.63%	96.09%	97.72%	99.06%	99.26%	95.46%	97.15%
Feb	97.99%	99.32%	95.36%	97.23%	99.00%	99.75%	95.09%	96.95%
Mar	99.21%	99.50%	98.04%	98.78%	99.89%	99.97%	97.98%	98.52%
Apr	99.56%	99.71%	98.78%	99.21%	99.75%	99.94%	98.57%	99.04%
May	99.49%	99.50%	98.21%	98.91%	99.70%	100.00%	98.08%	98.71%
Jun	99.78%	99.83%	98.75%	99.26%	99.79%	99.97%	98.69%	99.15%
Jul	99.73%	99.81%	99.09%	99.33%	99.89%	100.00%	99.03%	99.22%
Aug	99.57%	99.78%	98.83%	99.40%	99.83%	99.97%	98.75%	99.31%
Sep	98.93%	99.25%	96.93%	98.25%	99.47%	99.88%	96.82%	97.94%
Oct	96.90%	98.23%	97.23%	98.43%	99.73%	99.99%	96.81%	97.72%
Nov	97.81%	99.18%	97.74%	98.51%	99.63%	99.81%	97.43%	98.11%
Dec	99.01%	99.23%	98.04%	99.05%	99.66%	99.84%	98.71%	98.66%

Table 42. Ramstein Throughput Capacity, < = 30 Knot Crosswind (% per Month)

Ramstein Throughput Capability (% per Month) < = 30 Kt Crosswind								
Month	Ceiling		Visibility				Ceiling & Visibility	
	Cat I	Cat II	Cat I	Cat II	Cat IIIa	Cat IIIb	Cat I	Cat II
Jan	98.36%	99.17%	96.63%	98.25%	99.60%	99.80%	95.99%	97.69%
Feb	98.20%	99.52%	95.57%	97.44%	99.21%	99.96%	95.30%	97.16%
Mar	99.22%	99.52%	98.05%	98.79%	99.91%	99.99%	98.00%	98.53%
Apr	99.60%	99.75%	98.82%	99.25%	99.79%	99.99%	98.61%	99.08%
May	99.49%	99.50%	98.21%	98.91%	99.70%	100.00%	98.08%	98.71%
Jun	99.79%	99.85%	98.76%	99.28%	99.81%	99.99%	98.71%	99.17%
Jul	99.73%	99.81%	99.09%	99.33%	99.89%	100.00%	99.03%	99.22%
Aug	99.60%	99.81%	98.86%	99.42%	99.85%	100.00%	98.78%	99.34%
Sep	98.94%	99.26%	96.94%	98.26%	99.49%	99.89%	96.83%	97.96%
Oct	96.90%	98.23%	97.23%	98.43%	99.73%	99.99%	96.81%	97.72%
Nov	97.90%	99.28%	97.83%	98.61%	99.72%	99.90%	97.53%	98.21%
Dec	99.17%	99.40%	98.20%	99.21%	99.83%	100.00%	98.87%	98.82%

Table 43. Spangdahlem Throughput Capacity, < = 20 Knot Crosswind (% per Month)

Spangdahlem Throughput Capability (% per Month) < = 20 Kt Crosswind								
Month	Ceiling		Visibility				Ceiling & Visibility	
	Cat I	Cat II	Cat I	Cat II	Cat IIIa	Cat IIIb	Cat I	Cat II
Jan	88.23%	97.11%	86.47%	89.76%	94.89%	98.86%	85.70%	89.56%
Feb	92.84%	97.57%	88.01%	91.31%	95.34%	98.20%	87.77%	91.28%
Mar	98.17%	98.82%	97.41%	98.33%	98.95%	99.09%	97.20%	98.24%
Apr	98.94%	99.26%	98.47%	98.88%	99.28%	99.33%	98.40%	98.86%
May	99.52%	99.69%	99.07%	99.31%	99.61%	99.77%	99.06%	99.29%
Jun	99.68%	99.78%	99.40%	99.67%	99.99%	99.99%	99.38%	99.57%
Jul	99.54%	99.61%	99.21%	99.46%	99.66%	99.83%	99.14%	99.31%
Aug	99.41%	99.72%	98.84%	99.15%	99.54%	99.83%	98.80%	99.13%
Sep	98.92%	99.39%	97.88%	98.56%	99.31%	99.65%	97.88%	98.46%
Oct	97.50%	98.87%	95.70%	97.04%	98.79%	99.69%	95.32%	96.85%
Nov	95.19%	98.63%	93.43%	95.90%	98.33%	99.47%	92.67%	95.71%
Dec	93.31%	98.66%	91.12%	94.35%	97.69%	99.44%	90.17%	94.26%

Table 44. Spangdahlem Throughput Capacity, < = 25 Knots (% per Month)

Spangdahlem Throughput Capability (% per Month) < = 25 Kt Crosswind								
Month	Ceiling		Visibility				Ceiling & Visibility	
	Cat I	Cat II	Cat I	Cat II	Cat IIIa	Cat IIIb	Cat I	Cat II
Jan	88.70%	97.58%	86.94%	90.23%	95.36%	99.33%	86.17%	90.03%
Feb	93.72%	98.45%	88.88%	92.19%	96.22%	99.08%	88.65%	92.16%
Mar	98.74%	99.38%	97.97%	98.90%	99.52%	99.65%	97.77%	98.80%
Apr	99.56%	99.88%	99.08%	99.49%	99.89%	99.94%	99.01%	99.47%
May	99.69%	99.87%	99.25%	99.49%	99.78%	99.95%	99.23%	99.46%
Jun	99.54%	99.64%	99.26%	99.53%	99.85%	99.85%	99.24%	99.43%
Jul	99.69%	99.76%	99.35%	99.61%	99.81%	99.97%	99.29%	99.46%
Aug	99.56%	99.87%	98.99%	99.30%	99.69%	99.97%	98.95%	99.27%
Sep	99.14%	99.61%	98.10%	98.78%	99.53%	99.88%	98.10%	98.68%
Oct	97.66%	99.03%	95.86%	97.20%	98.95%	99.85%	95.48%	97.02%
Nov	95.44%	98.88%	93.68%	96.15%	98.58%	99.72%	92.92%	95.96%
Dec	93.53%	98.88%	91.34%	94.58%	97.92%	99.66%	90.40%	94.49%

Table 45. Spangdahlem Throughput Capacity, < = 30 Knot Crosswind (% per Month)

Spangdahlem Throughput Capability (% per Month) < = 30 Kt Crosswind								
Month	Ceiling		Visibility				Ceiling & Visibility	
	Cat I	Cat II	Cat I	Cat II	Cat IIIa	Cat IIIb	Cat I	Cat II
Jan	88.97%	97.85%	87.20%	90.50%	95.63%	99.60%	86.44%	90.30%
Feb	94.14%	98.87%	89.30%	92.60%	96.64%	99.49%	89.06%	92.57%
Mar	98.99%	99.64%	98.23%	99.15%	99.77%	99.91%	98.02%	99.06%
Apr	99.61%	99.93%	99.14%	99.54%	99.94%	100.00%	99.07%	99.53%
May	99.74%	99.92%	99.30%	99.54%	99.84%	100.00%	99.29%	99.52%
Jun	99.69%	99.79%	99.42%	99.68%	100.00%	100.00%	99.39%	99.58%
Jul	99.69%	99.76%	99.35%	99.61%	99.81%	99.97%	99.29%	99.46%
Aug	99.56%	99.87%	98.99%	99.30%	99.69%	99.97%	98.95%	99.27%
Sep	99.24%	99.71%	98.19%	98.88%	99.63%	99.97%	98.19%	98.78%
Oct	97.67%	99.05%	95.87%	97.22%	98.97%	99.87%	95.50%	97.03%
Nov	95.53%	98.96%	93.76%	96.24%	98.67%	99.81%	93.00%	96.04%
Dec	93.70%	99.05%	91.51%	94.74%	98.08%	99.83%	90.56%	94.65%

Weather constrained throughput then becomes the percent of operations that can occur (i.e. the percents in Table 37-45) times the unconstrained data from Table 36 (i.e. the cargo and passenger throughput per day). Thus, the data in Tables 37 – 45 become a correction factor for all flight operations with crosswind and weather category limitations.

Table 46 is an example of the application of Tables 37 – 45. The example scenario is as follows: ceiling and visibility requirements and landing in dry conditions (30-knot crosswind limit) in January.

Table 46, Throughput Example (pax and Short tons/day)

	Rhein Main	Ramstein	Totals PIK I	Ramstein	Spangdahlem	Totals PIK II
Uncorrected						
Pax	7866.00	3942.00	**11808.00**	10494.00	7884.00	**18378.00**
Cargo	11215.00	7990.20	**19205.20**	10541.00	6620.40	**17161.40**
Correction Factor	98.70%	97.69%		97.69%	90.30%	
Corrected						
Pax	7763.74	3850.94	**11614.68**	10251.59	7119.25	**17370.84**
Cargo	11069.21	7805.63	**18874.83**	10297.50	5978.22	**16275.72**

Table 46 shows the correction factor applied to the data from Table 35. The totals are of interest in that PIK I data needed to be corrected as well as PIK II data. The uncorrected percent change in existing capacity is 155.64% (18378/11808) for passengers and 89.36% (17161.4/19205.2) for cargo. The corrected figures show a percent change of 2005 capacity as 149.56% (17370.84/11614.68) for passengers and 86.23% (16275.72/18874.83) for cargo. The key to this example is that the capacity is less than previously thought because weather corrections were not applied to the throughput data. A planner would be counting on the 89.36% for cargo, but would only be getting the 86.23% of capacity.

Summary

Throughput calculations must be corrected for weather conditions to accurately plan for contingencies. The data in Tables 37 – 45 list the correction factors that must be applied to account for the differences in weather between the bases in question.

VII. Findings and Recommendations

The weather correction factors for category and crosswind conditions are the overall finding of this report. However, there were a couple of observations that could be investigated further.

The weather community does not report visibility in 50-meter increments. For this reason, Cat IIIa data is not as accurate as it could be. This would be a suggestion for future data to capture as it could validate or invalidate Cat III approach requirements for USAFE. As it stands, using visibility only, Cat IIIa approaches, if installed would give approximately 5.13% greater capability for Spangdahlem AB in the month of January and 3.34% for December for AMC aircraft.

As stated in the Methodology section, negotiations with the German authorities and townspeople around Spangdahlem will have to be conducted in order to procure rights to 24-hour operations. It is extremely important that United States Federal and Air Force leadership engage German authorities on this issue. If the rights to 24-hour operations are not procured it could significantly alter the results of this study.

Finally, due to different weather requirements of AMC and USAFE assets, in regard to ceiling and visibility, it is recommended from this study on weather factors, that mobility assets not be CHOP'd to USAFE. If control is needed, TACON of AMC assets is a good compromise. With TACON, USAFE would be able to control the assets while these assets use AMC criterion for weather minimums and thus retain the ability to apply better weather correction factors.

Bibliography

Air Mobility Command. 1998 Air Mobility Master Plan. AMMP 98, Scott AFB IL: HQ AMC, 24 October 1997.

Air Force Combat Climatology Center, 151 Patton Ave, Room 120, Asheville, N.C. 28801.

Air Force Manual (AFM) 11-217, Volume One, "Flying Operations - Instrument Flight Procedures", 1 April 1996.

Air Force Manual (AFM) 15-111, "Determination of RVR; Observing and Reporting Procedures", HQ Air Weather Service, Scott AFB, IL, Sep 1996.

Department of Defense (DOD), Flight Information Publication (FLIP), Supplement Europe, North Africa, and Middle East, National Imagery and Mapping Agency, St. Louis, MO., 22 April to 20 May 1999.

Department of the Air Force. Air Force Basic Doctrine. Air Force Doctrine Document 1. HQ AFDC, September 1997.

Federal Aviation Administration (FAA), "Criteria For Approval of Category III Landing Weather Minima", Advisory Circular No: 120-28C, 9 March 1984.

Harwick, Robert E., Chief Scientific Services and Standardization, HQ AMC/DOWO, e-mail communication, 6 April 1999.

McNabb, Duncan. Commander TACC, Brigadier General USAF, Scott AFB IL. Personal interview. 18 February 1999.

Motz, Wolfgang H., Host Nation Legal Advisor, Office of the Staff Judge Advocate, HQ USAFE, Ramstein AB, Germany, Personal Interview 9 February 1999 and Telephone Interview 2 June 1999.

National Defense University, Institute for National Strategic Studies. 1998 Strategic Assessment: Engaging Power for Peace. Washington DC: U.S. Government Printing Office, 1998.

Schmokel, Fred, Chief XPR HQ USAFE, Ramstein AB, Germany, Major USAF, Personnel Interview 8 February 1999 and Telephone Interview 2 June 1999.

Status of United States Forces in the Federal Republic of Germany, 14 UST 689. TIAS 5352. Signed at Bonn FRG August 3, 1959. Entered into force July 1, 1963.

Supplementary Agreement to the NATO Status of Forces Agreement – Multilateral Status of Forces in the Federal Republic of Germany. 14 UST 531. TIAS 5351, Government Printing Office, Washington D.C. October 23, 1954, Signed at Bonn FRG, August 3, 1959.

Thompson, Jonathan, Staff Meteorologist, Captain USAF, Air Force Combat Climiatology Center, 151 Patton Ave, Room 120, Asheville, N.C. 28801, Telephone interview, 24 May 1999.

United States Air Forces Europe (USAFE) and HQ AMC, "Rhein Main Air Base Capabilities Analysis", HQ USAFE, HQ AMC, 621 AMSG, 623 AMSS, 626 AMSS, 7 October 1998.

Vita

Major Richard P. MacKeen was born on 1 March 1964 at Ganado, Arizona. He spent most of his youth in the states of Oklahoma, Massachusetts, and New Mexico, graduating from Window Rock High School, Arizona in June of 1982. He then attended the United States Air Force Academy and graduated with a Bachelor of Science degree in Aeronautical Engineering on 28 May 1986.

Following graduation from USAFA, he attended Undergraduate Pilot Training at Vance Air Force Base, Oklahoma. His first assignment as a rated pilot was to remain at Vance AFB as a First Assignment Instructor Pilot in the T-38. In October of 1990, he received orders to Kadena Air Base Japan as a KC-135 Pilot. During his tour in Japan he received extensive experience in operations, subsequently upgrading to Instructor Pilot. He served as the Squadron Life Support Officer, Wing War Plans Officer, and Squadron Assistant Flight Commander. Following this tour, he reported for duty at the 100th Operational Support Squadron at RAF Mildenhall, United Kingdom where he became Chief of Coronet Plans. While in the OSS, he received a Master of Arts in Managerial Economics from the University of Oklahoma. After more than 50 Trans-oceanic missions, moving over 600 fighter aircraft, he became the Flight Commander of the European Tanker Task Force. In May of 1998, Major MacKeen was assigned to the Air Mobility Warfare Center, Advanced Study of Air Mobility (ASAM) program. After Graduation and subsequent Masters of Science in Air Mobility, he will work Intransit Visibility (ITV) issues at USTRANSCOM/J3/4 at Scott Air Force Base, Illinois.

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